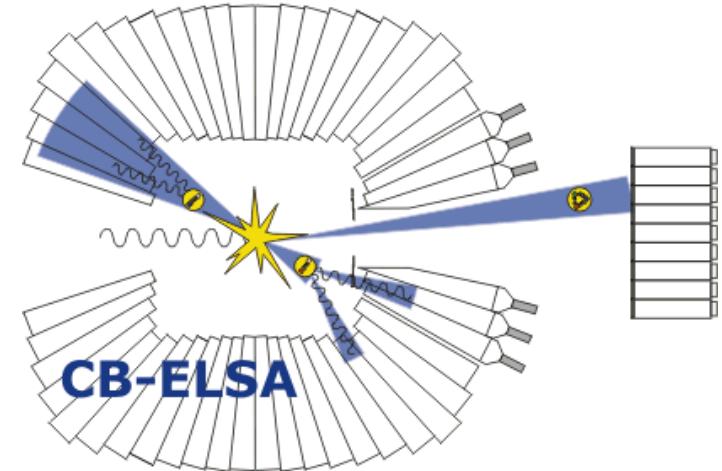


UNI
BASEL



Double Polarized Experiment

@ CB-ELSA

Irakli Keshelashvili
University of Basel

- *Physics*

- Missing Resonances
Iso-Spin Filter

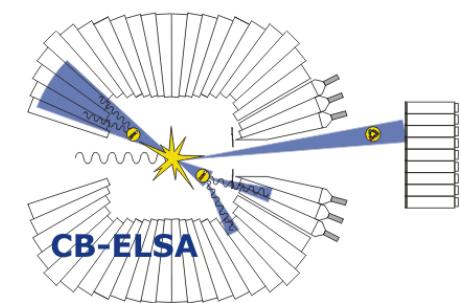
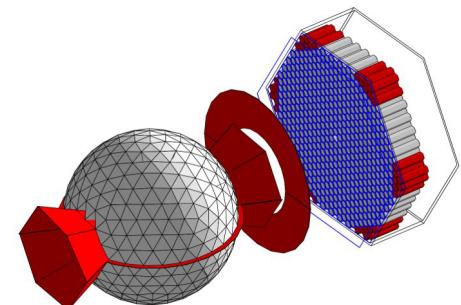
- *Experiment*

- MAMI @ Mainz
ELSA @ Bonn

- *Results*

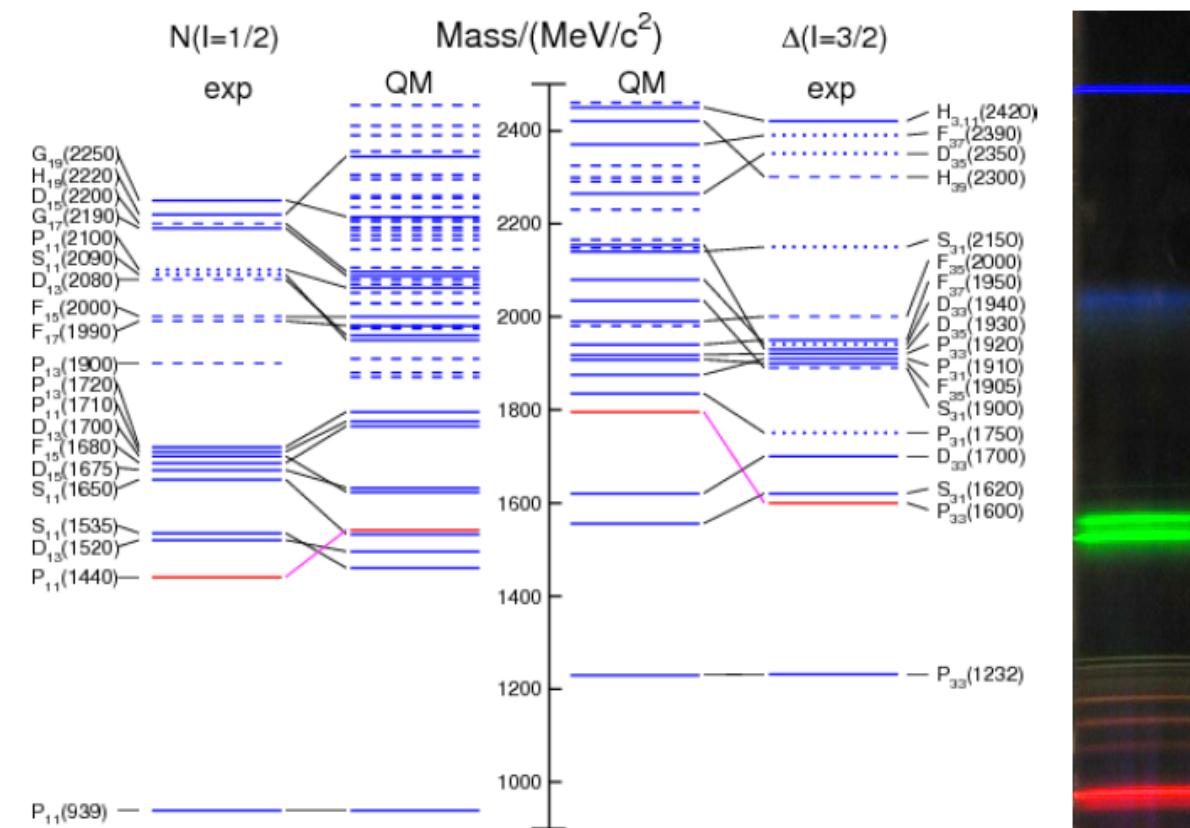
- Liquid D & ${}^3\text{He}$ -Target
D-Butanol Target

- *Conclusion*



known excited states in constituent quark model

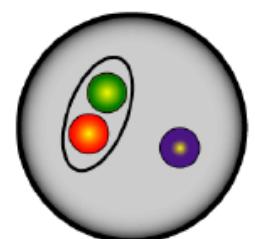
(Capstick & Roberts)



ordering of low lying states ?
missing resonances ?

degrees of freedom ?

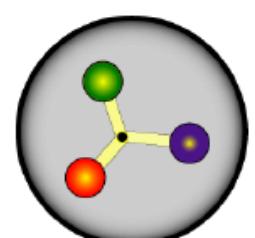
► 3 constituent quarks



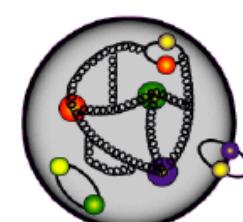
► quark-diquark

► quark flux-tube

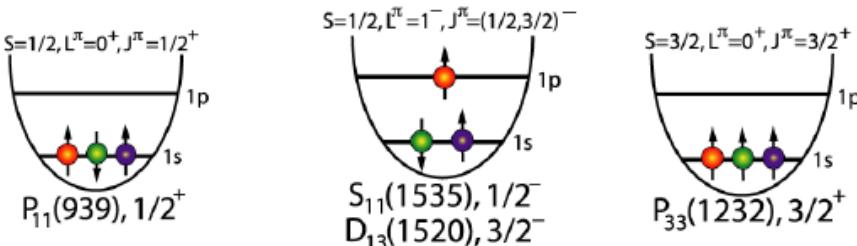
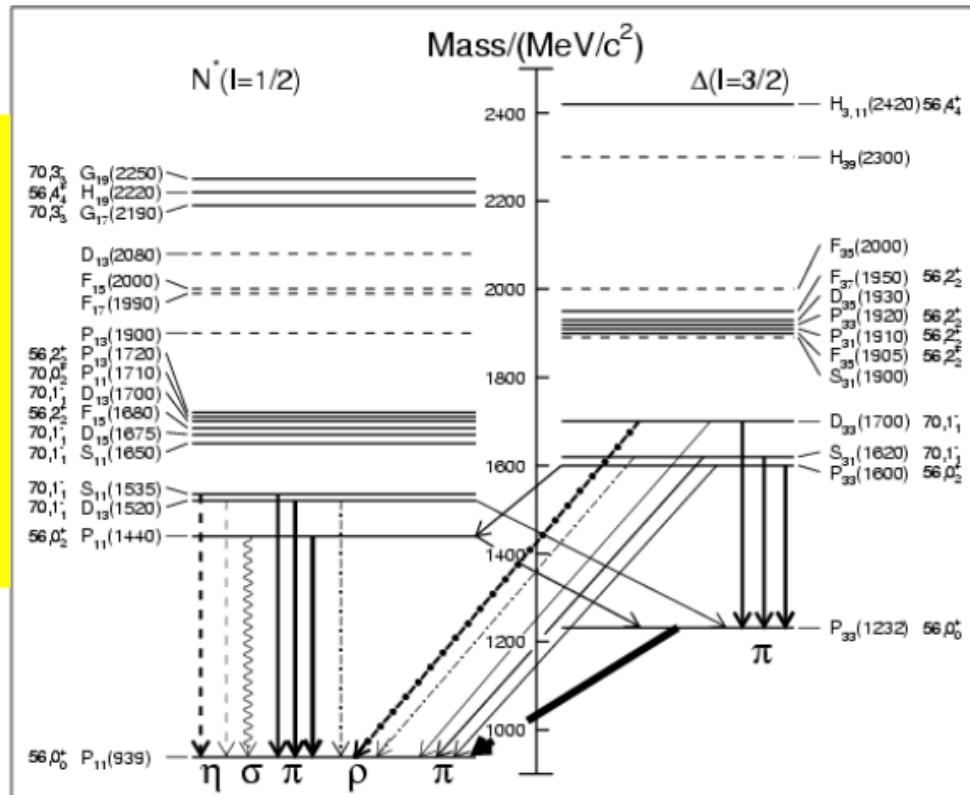
► coupled channel



dynamics



excited states of the nucleon



Since: $\pi^0 - I^G(J^{PC}) 1^-(0^-)$

$\eta - I^G(J^{PC}) 0^-(0^-)$

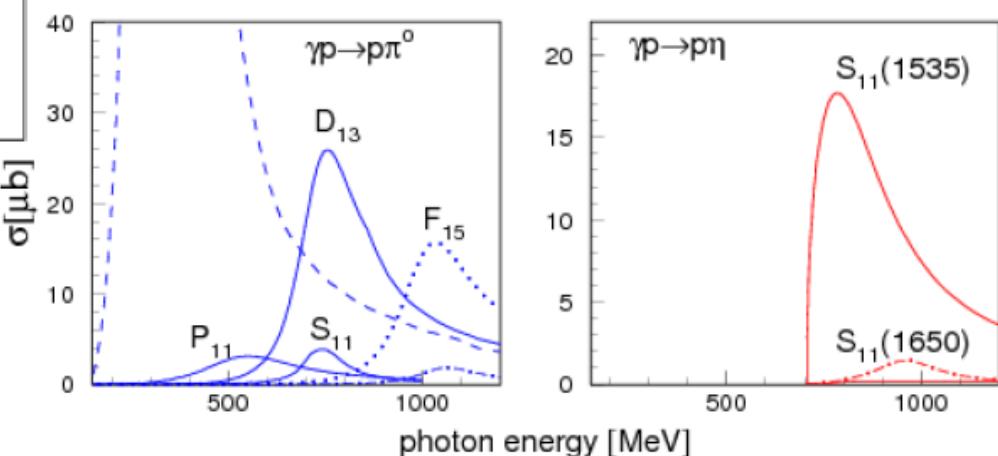
η iso-spin filter

$N^*/\Delta^* \rightarrow \Delta\pi$

$N^* \rightarrow N^*\eta/\pi$

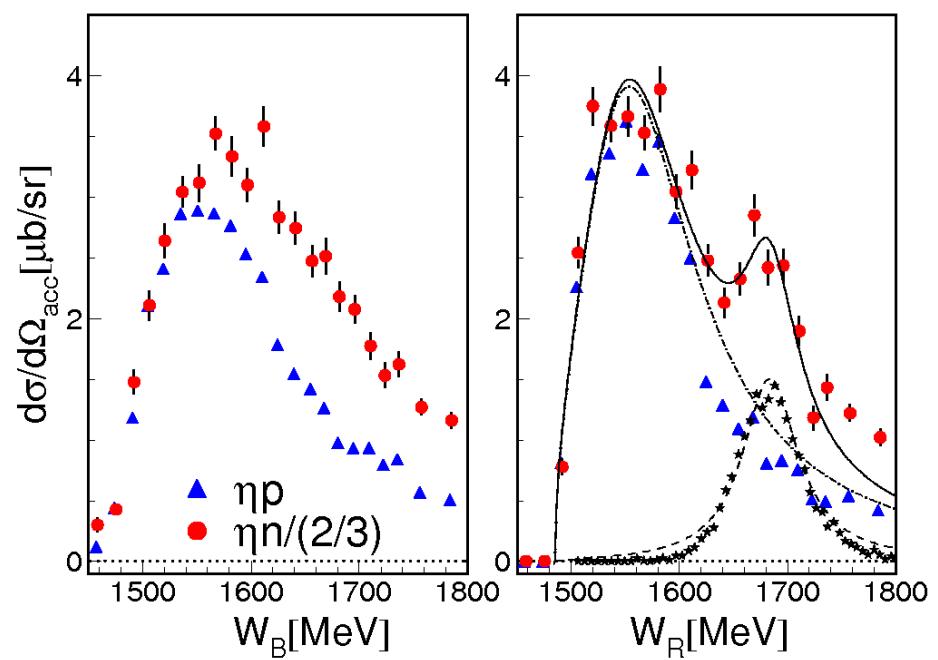
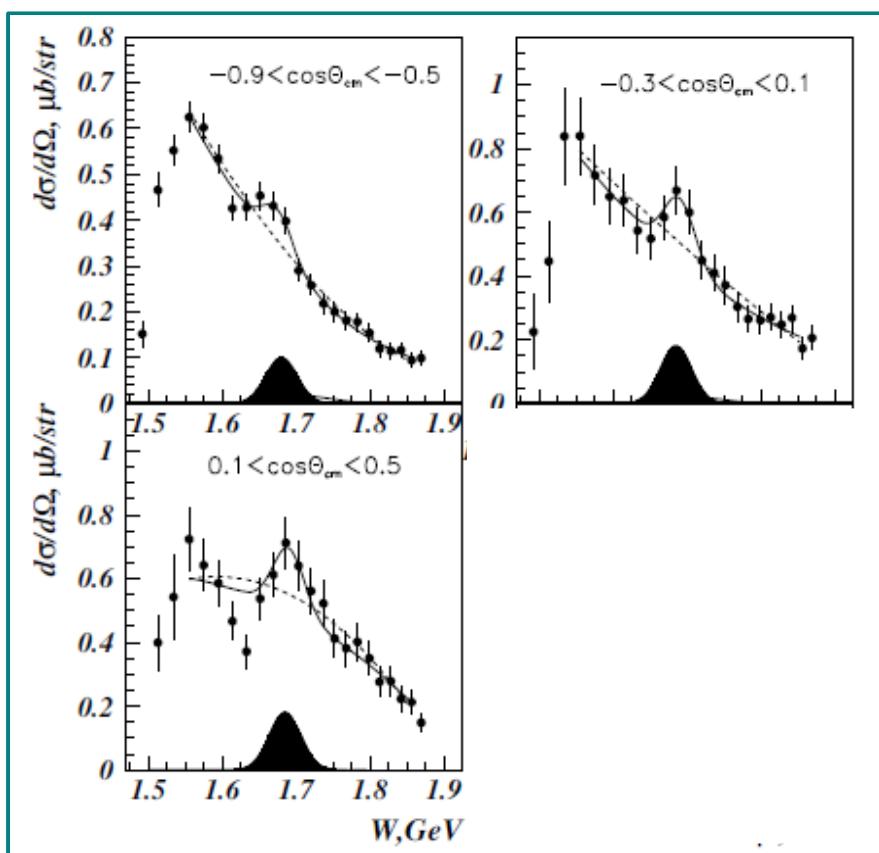
$N^*/\Delta^* \rightarrow N^*\pi$

$\Delta^* \rightarrow \Delta\eta$



Neutron “Anomaly”

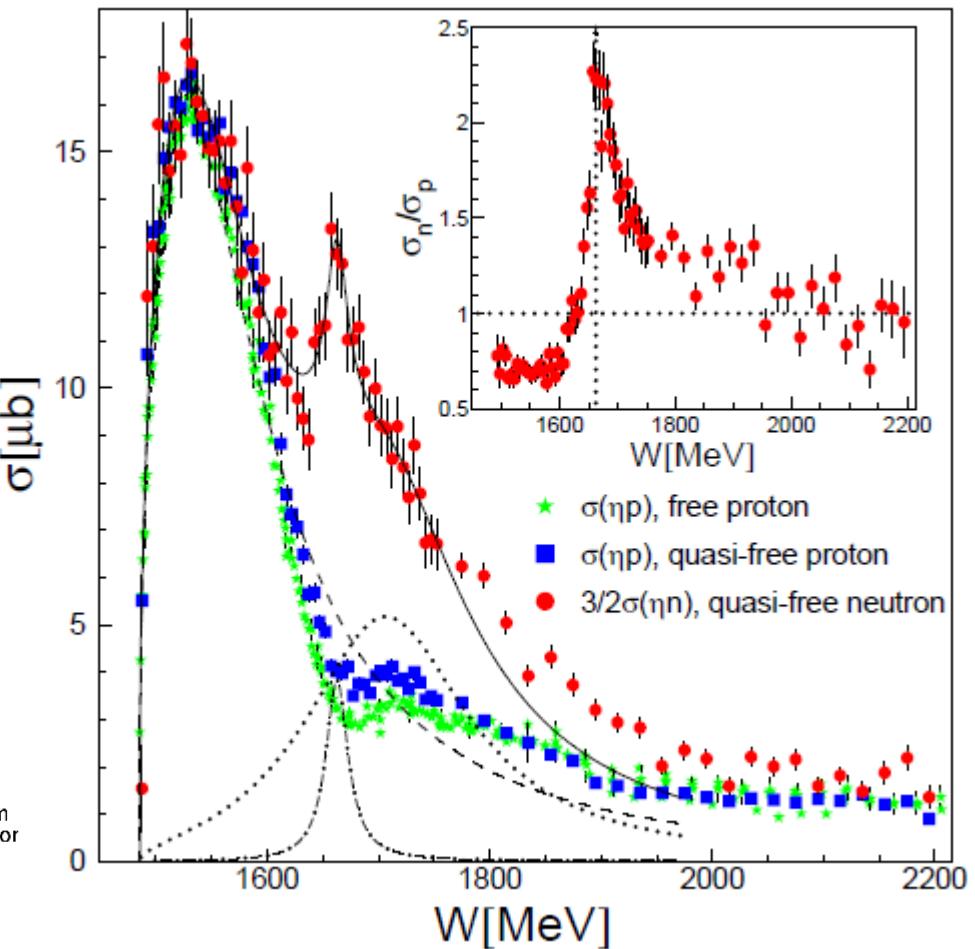
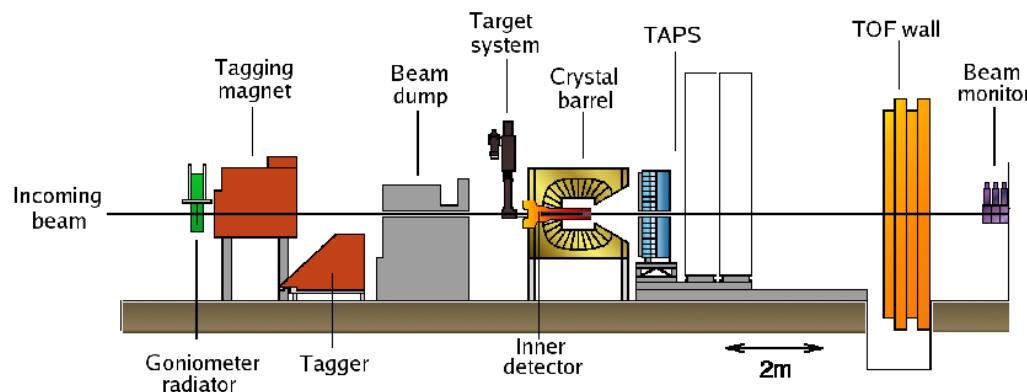
- 1) first discovered at **GRAAL** collaboration: V.Kuznetsov et al. Phys. Lett. B647
- 2) confirmed at LNS in Sendai: F. Miyahara et al. Prog. Theor. Phys. Suppl. 168
- 3) CB-ELSA/TAPS in Bonn : I. Jaeglé et al., Phys. Rev. Lett. 100 (2008) 252002



$W = 1683$ MeV
 $\Gamma < 60 +/- 20$ MeV

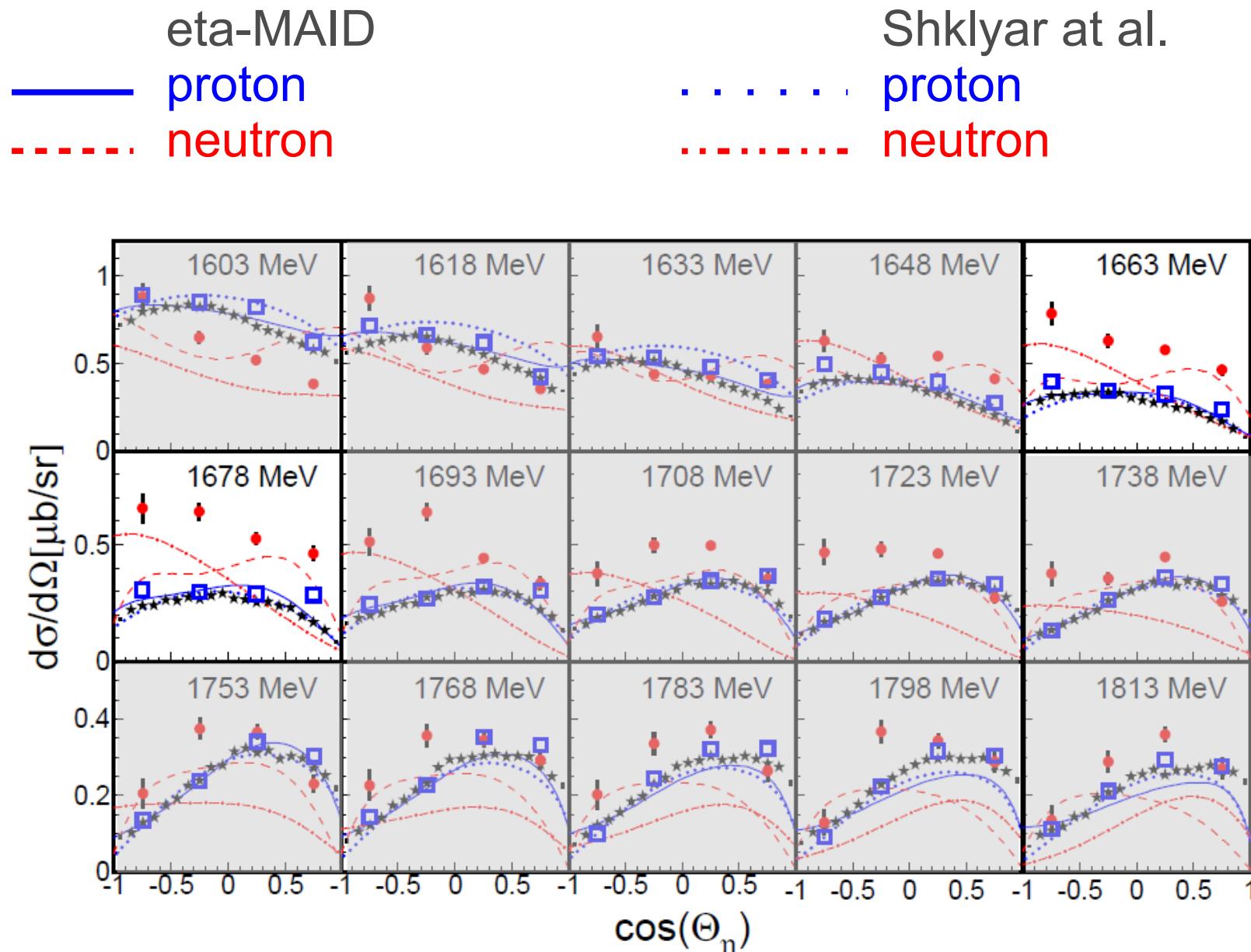
Neutron “Anomaly”

$S_{11}(1535)$	W^\dagger [MeV]	Γ^\dagger [MeV]	$A_{1/2}^\ddagger$ [10^{-3} GeV $^{-1/2}$]
PDG	1535 ± 10 (1510 ± 10)	150 ± 25 (170 ± 80)	$A_{1/2}^p: 90 \pm 30$ $A_{1/2}^n: 46 \pm 27$
BoGa [§]	- (1505 ± 20)	- (145 ± 25)	$A_{1/2}^p: 90 \pm 25$ $A_{1/2}^n: 80 \pm 20$
$\gamma p \rightarrow p\eta$	1536 ± 1	170 ± 2	106 ± 1
$\gamma d \rightarrow (n)p\eta$	1544 ± 2	181 ± 13	109 ± 3
$\gamma d \rightarrow (p)n\eta$	1546 ± 3	176 ± 20	90 ± 4
$\gamma d \rightarrow (p)n\eta$			
$S_{11}(1535)$	1535 ± 4	166 ± 23	88 ± 6
‘broad BW’	1701 ± 15	180 ± 35	-
‘narrow BW’	1663 ± 3	25 ± 12	-



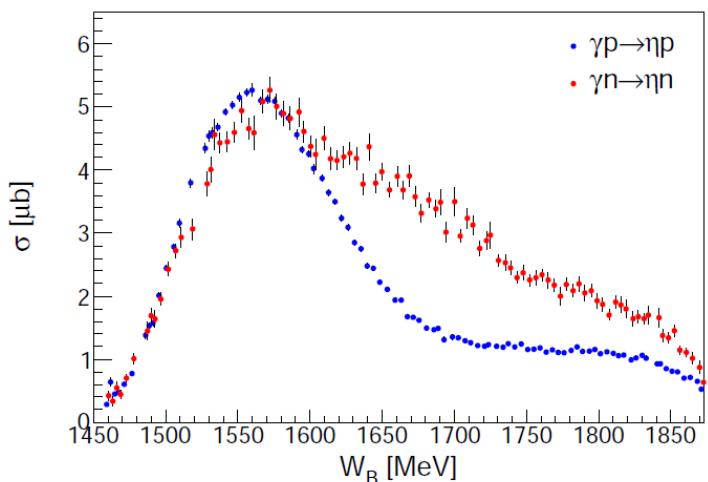
ELSA, I. Jaeglé et al., EPJ

High Resolution Analysis from CBELSA/TAPS

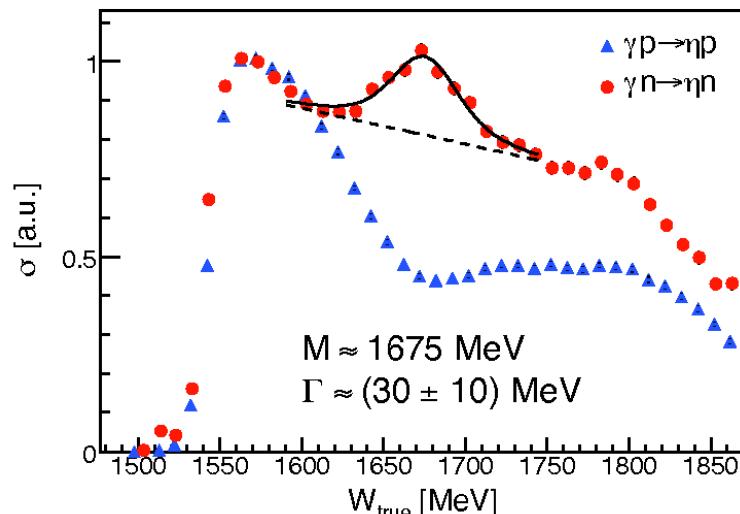
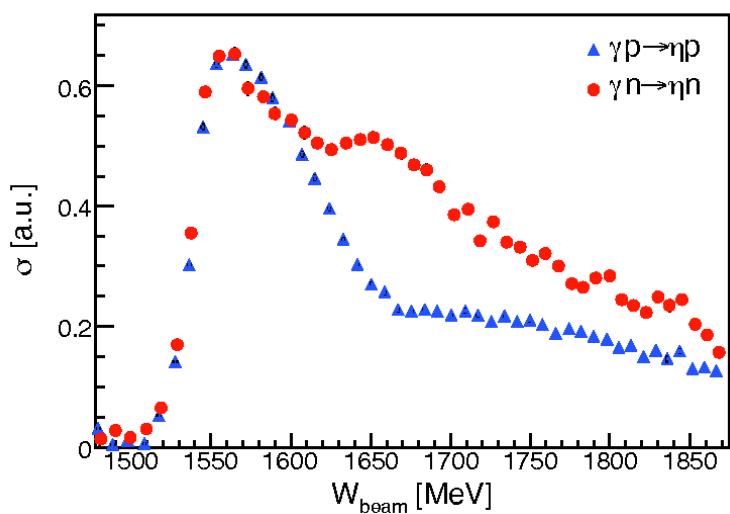
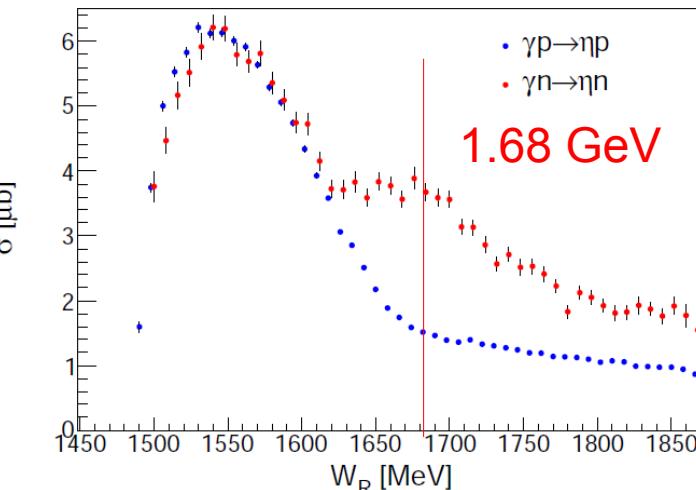


Neutron “Anomaly”

$$W_B^2 = (P_\gamma + P_{N,i})^2 = 2E_\gamma m_N + m_N^2$$

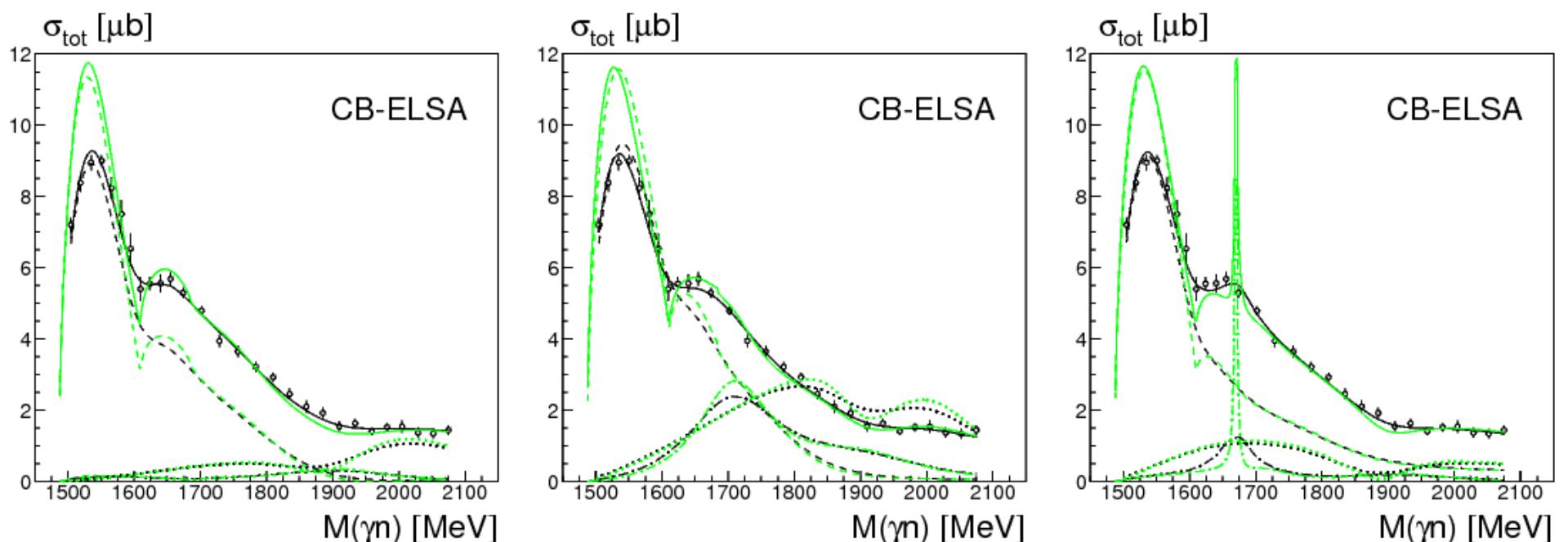


$$W_R^2 = (P_\eta + P_{N,f})^2$$



^3He (L.Witthauer)

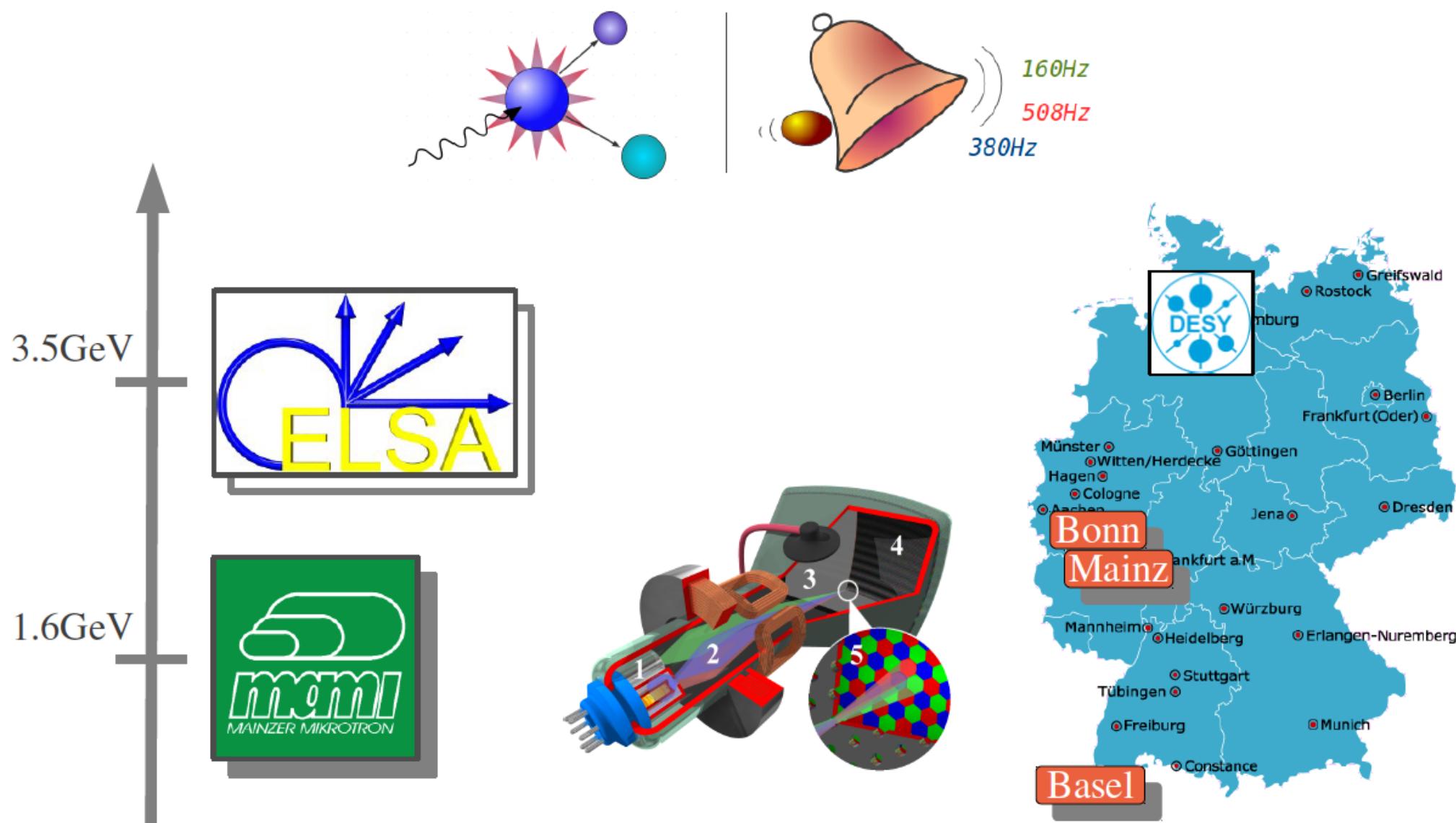
LD_2 (D. Werthmüller)



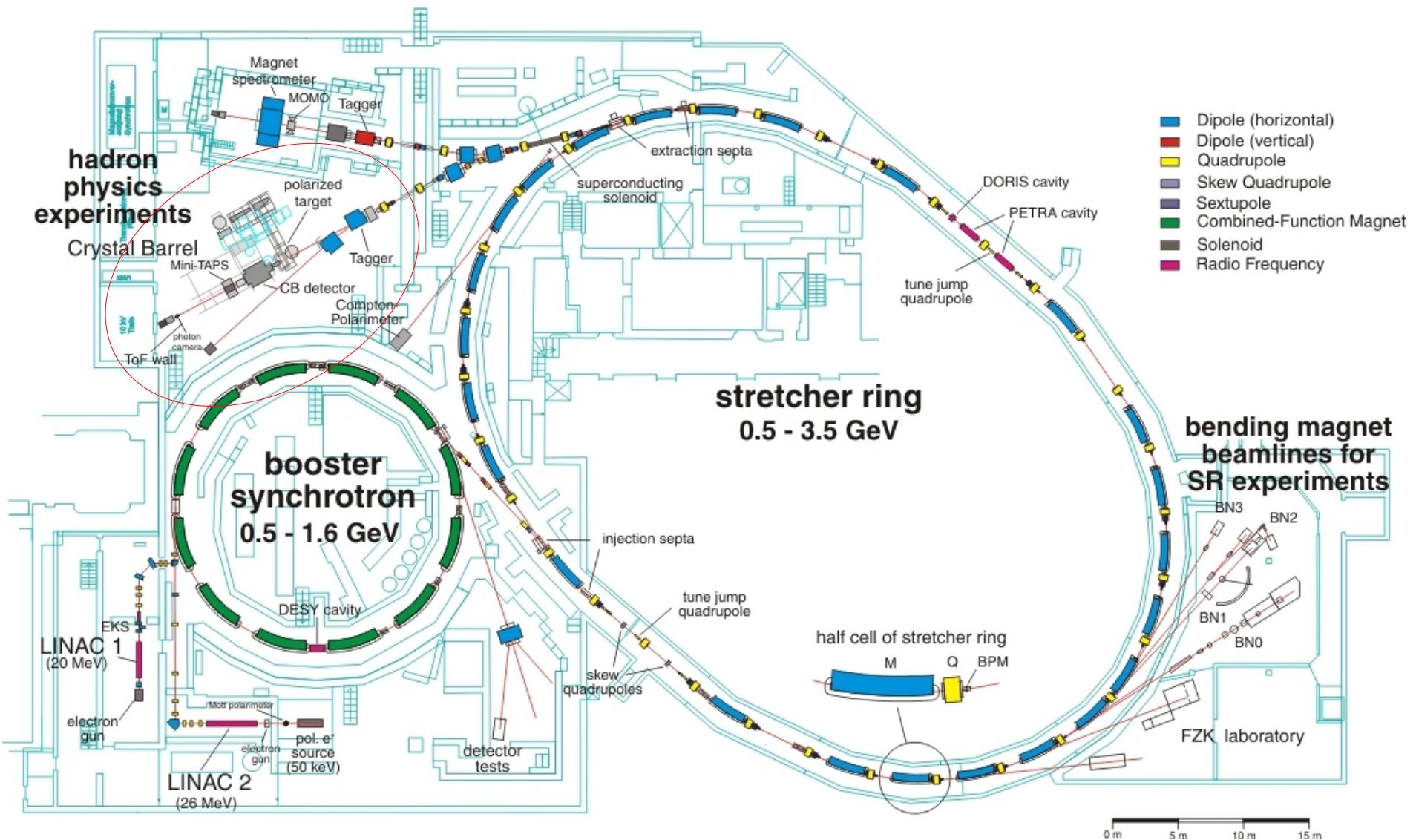
Different scenarios to reproduce 'bump' structure:

- left: Interference in S11-sector: adjusting phases etc.
- middle: Introduction of conventional (broad) P11 resonance
- right: Introduction of very narrow P11 resonance

Experiment

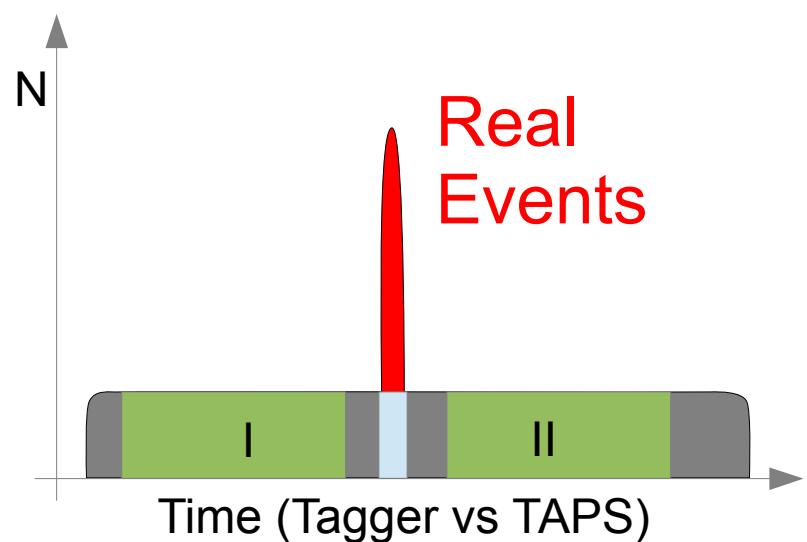
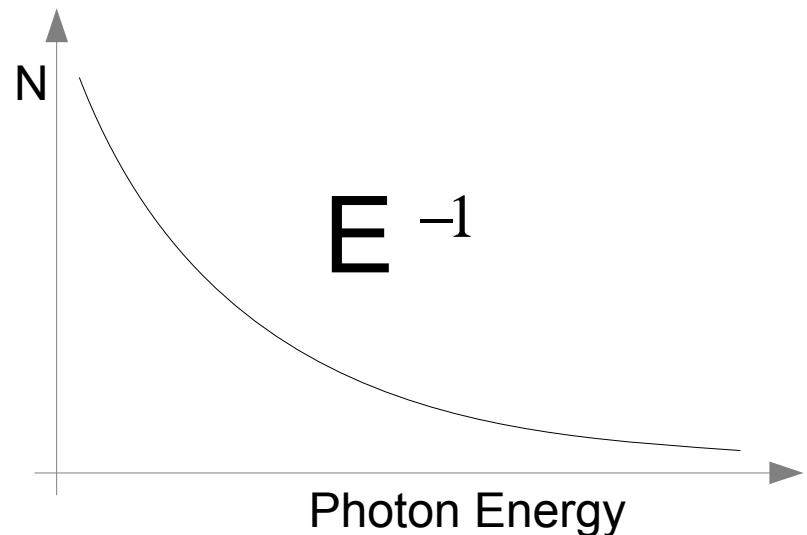
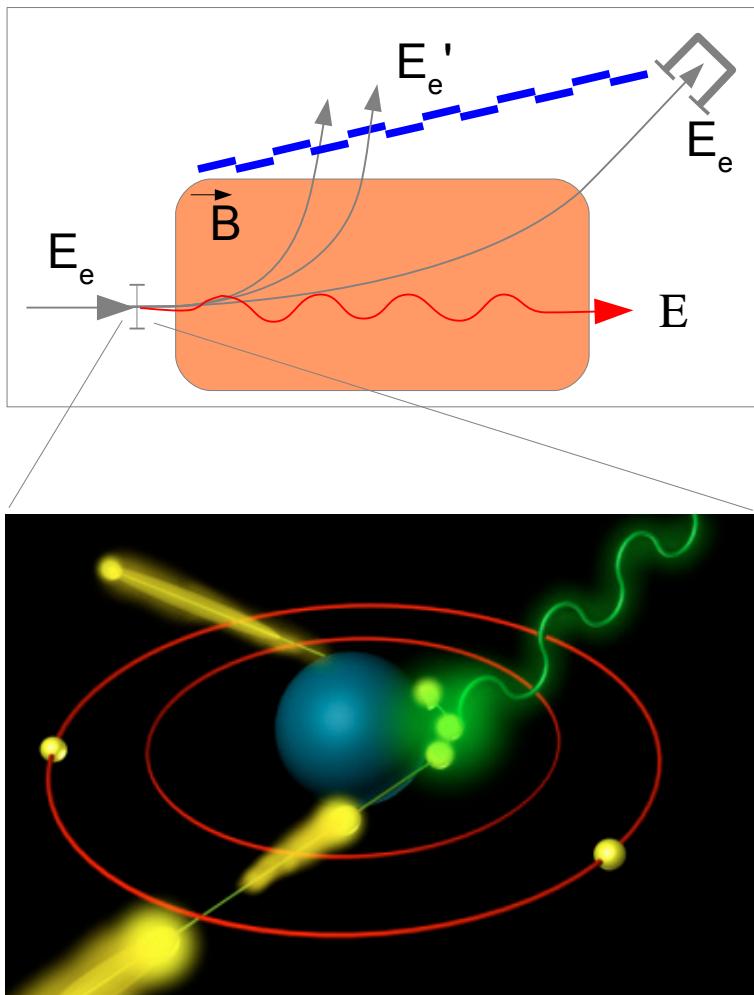


ELSA Elektronen-Stretcher-Anlage



Tagger system

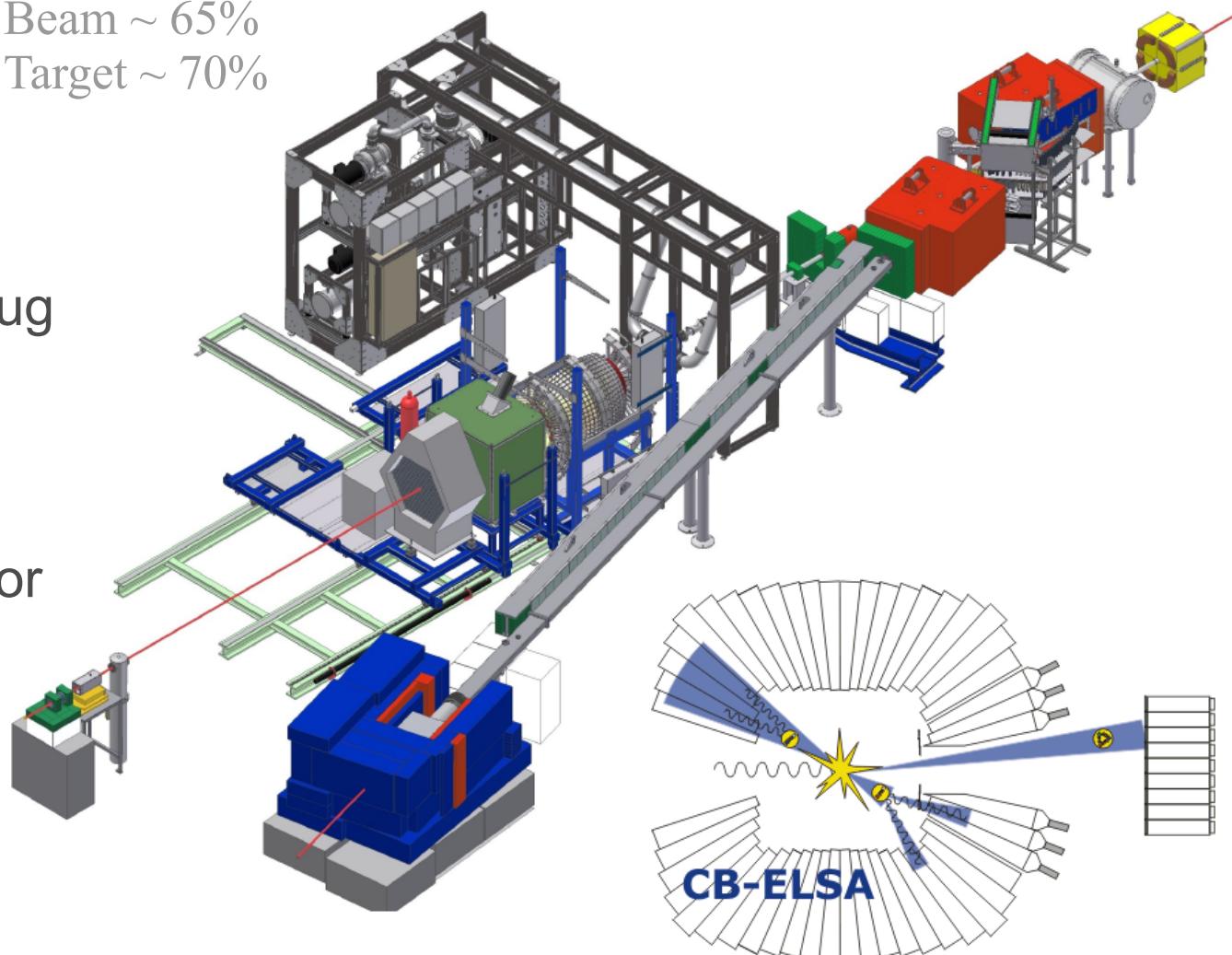
$$E = E_e - E_{e'}$$



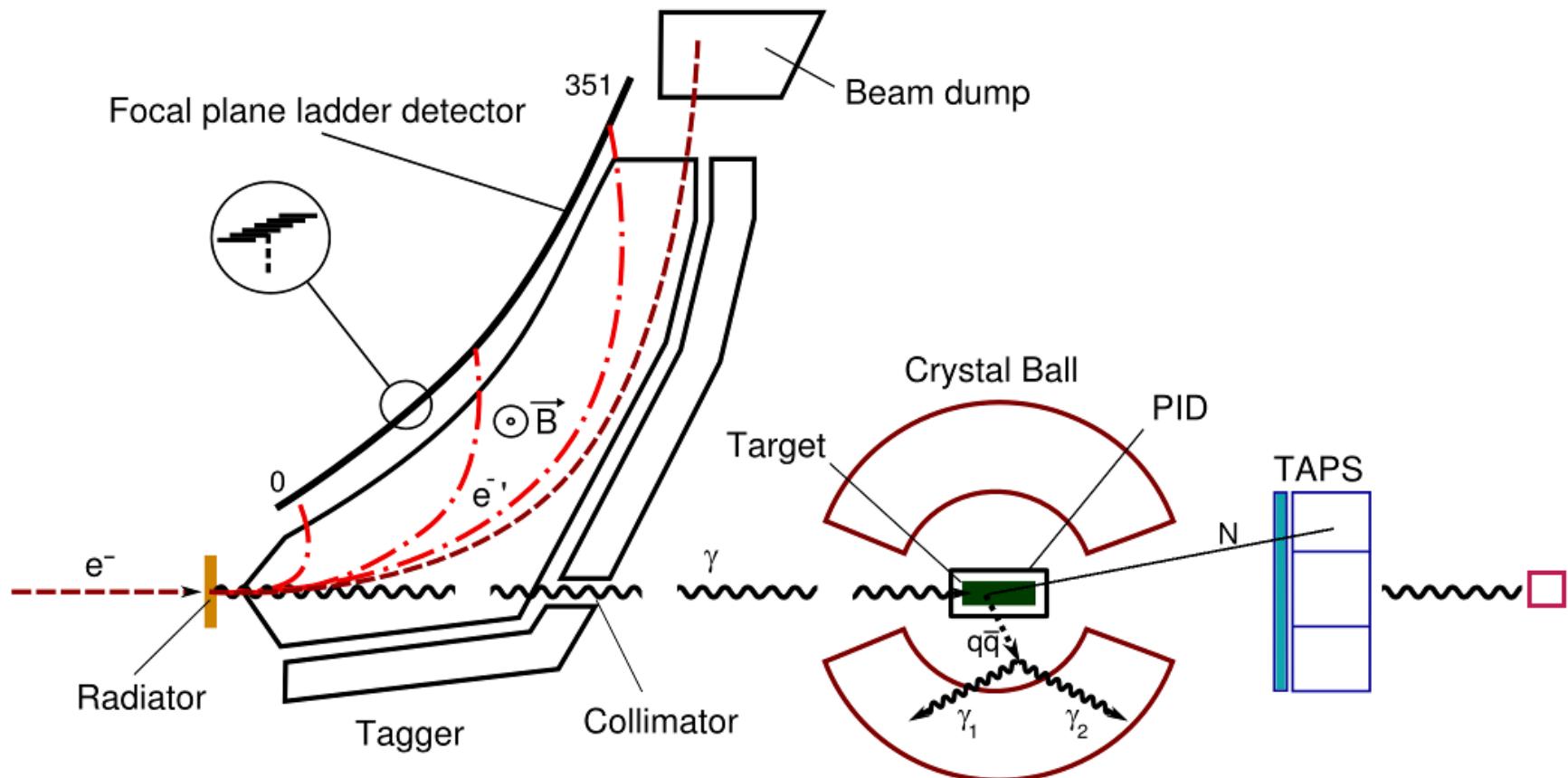
Crystal Barrel & TAPS @ ELSA

- Tagging System
- Polarized Target
- Inner Detector PID
- Crystal Barrel & FW Plug
- Gas Cherenkov
- Mini TAPS
- Gamma Intensity Monitor
- Beadmump

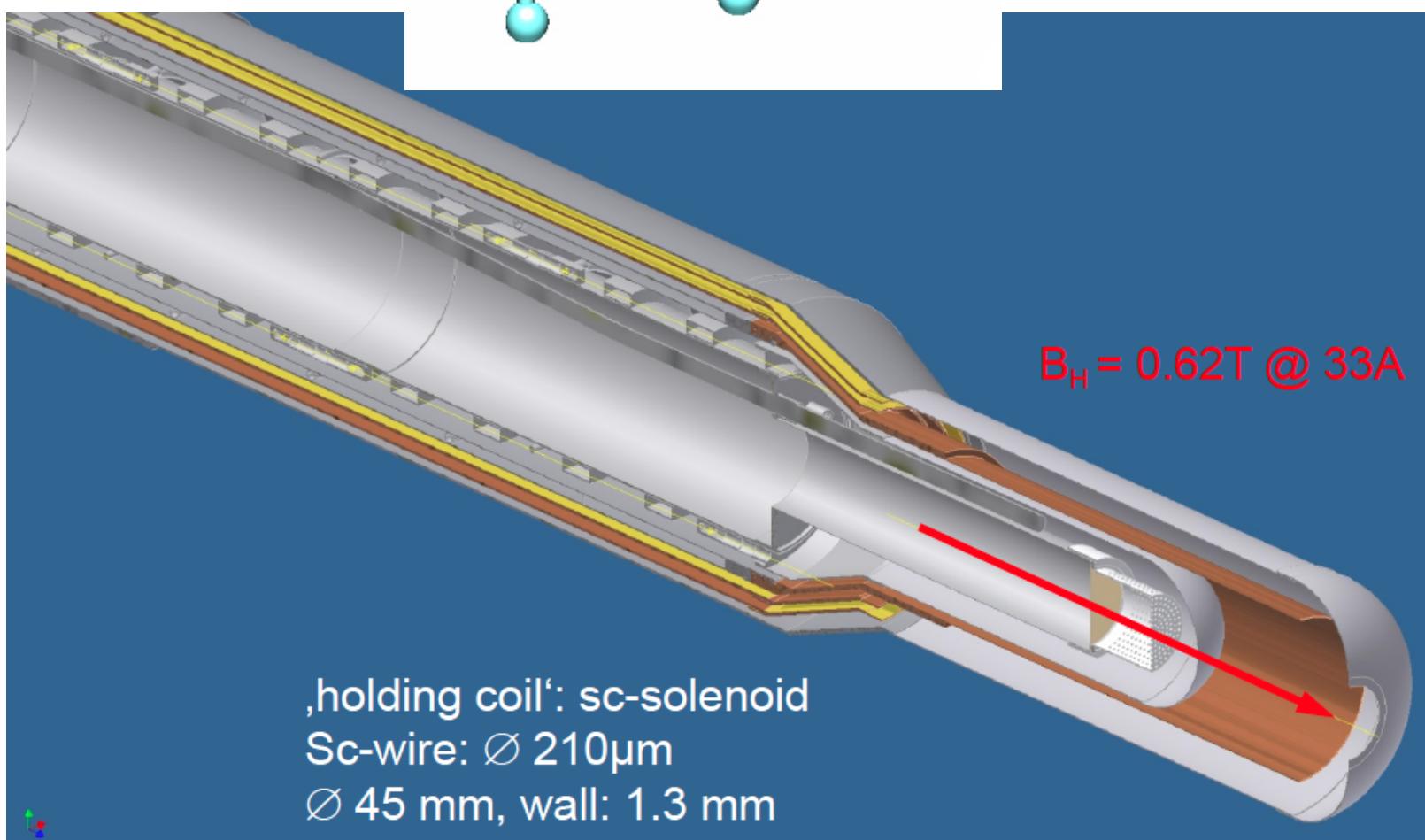
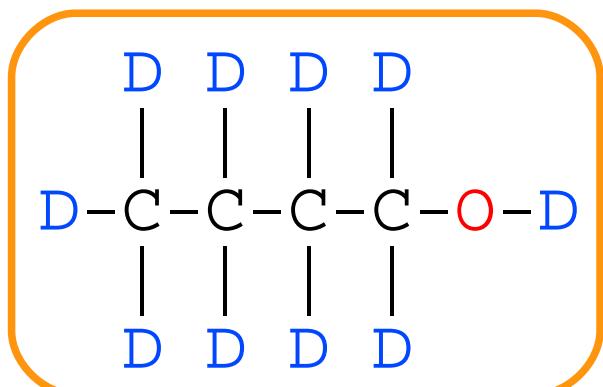
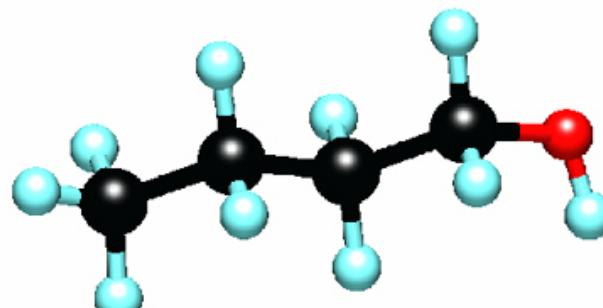
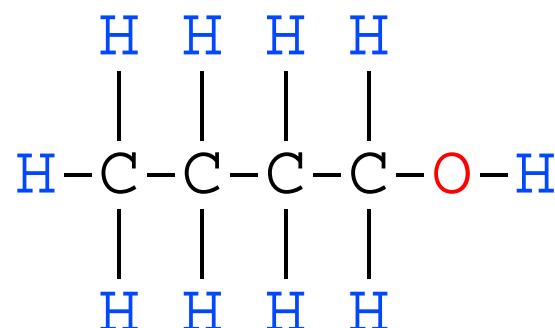
Electron beam 2.4GeV
Polarization:
Beam ~ 65%
Target ~ 70%



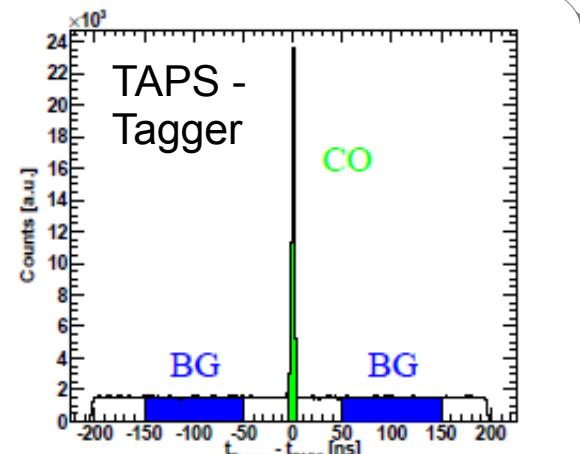
Crystal Ball & TAPS @ MAMI



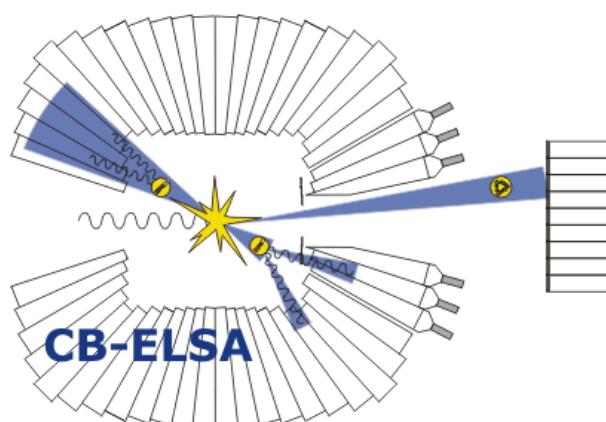
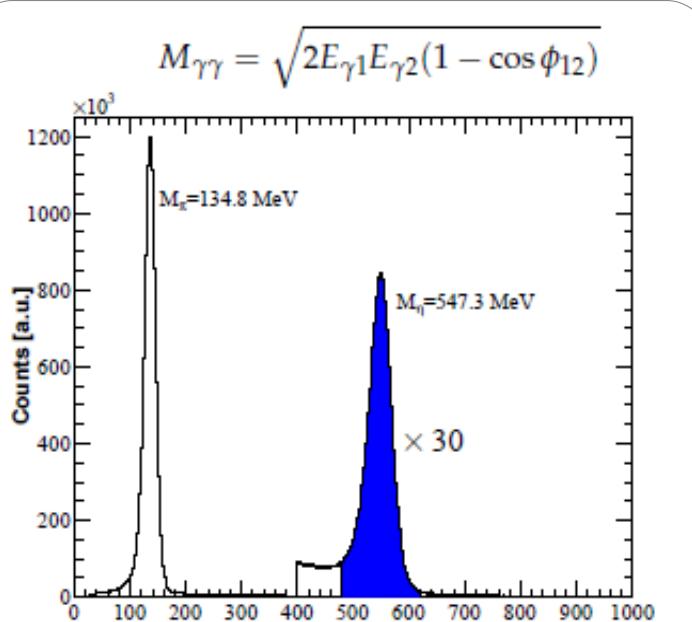
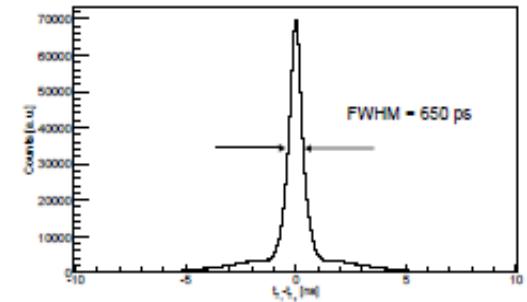
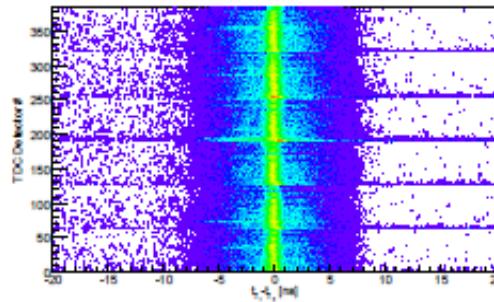
Why D-Butanol target?



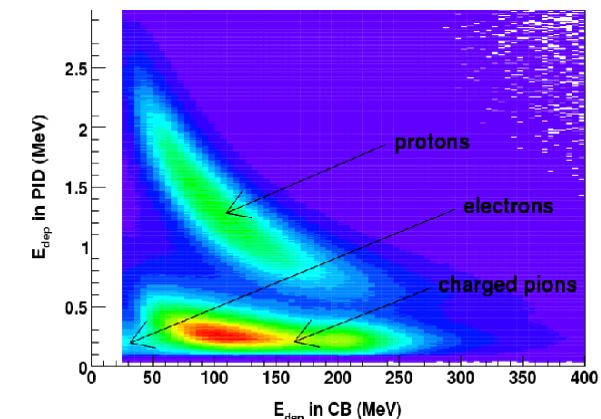
Data Analysis



TAPS Time



PID Scintillators



$$\frac{d\sigma}{d\Omega}(E_\gamma, \theta) = \frac{N_{event}(E_\gamma, \theta)}{\epsilon_{event}(E_\gamma, \theta) \cdot \Gamma_{BR} \cdot N_{target} \cdot N_{scaler}(E_\gamma) \cdot \epsilon_\gamma(E_\gamma) \cdot \Omega}$$

Experiment summary

Beam Energy	2350 MeV
Beam Current	0.6 nA
Photon Beam	circularly polarised
Mean beam Polarisaton	$\langle P_e \rangle \approx 61\% \quad (P_\gamma^{1\text{GeV}} \approx 33\%)$
D-Butanol Target	longitudinally polarised
Mean Target Polarisatin	$\langle P_T \rangle \approx 62\%$
Duration	8 Weeks 2011
Background Measurements	Carbon (1 Week 2011) LD ₂ (2 Weeks 2008)

PHYSICAL REVIEW

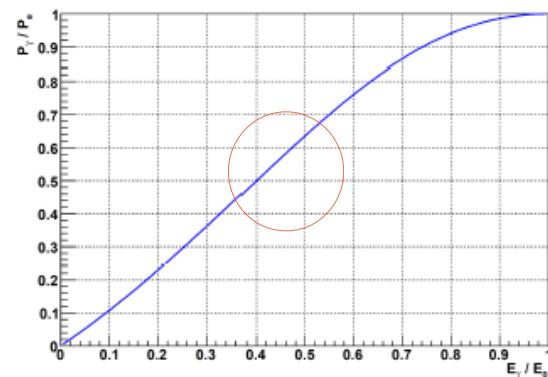
VOLUME 114, NUMBER 3

MAY 1, 1959

Photon and Electron Polarization in High-Energy Bremsstrahlung and Pair Production with Screening*

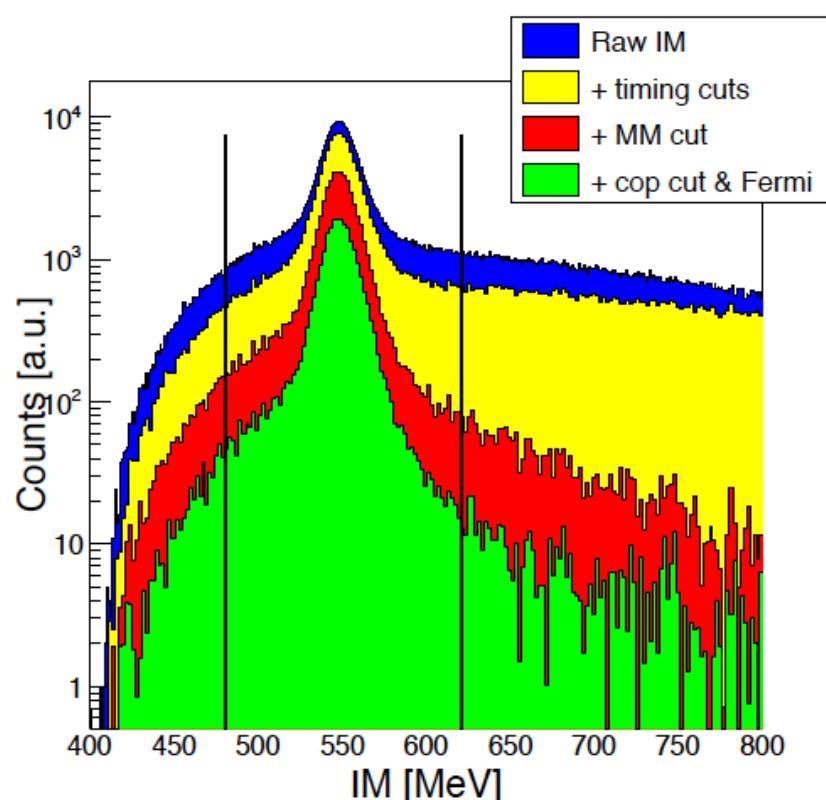
HAAKON OLSEN, *Fysisk Institutt, Norges Tekniske Høgskole, Trondheim, Norway*

$$P_\gamma = P_e \cdot \frac{E_\gamma(3+(1-E_\gamma))}{3-(2(1-E_\gamma))+3(1-E_\gamma)^2}$$

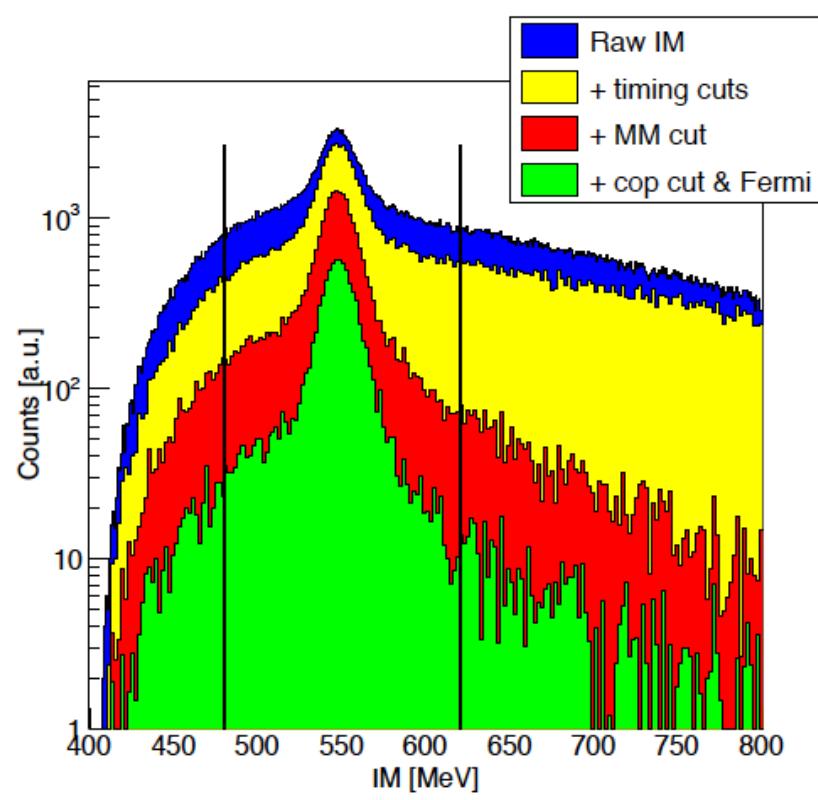


$\gamma N \rightarrow N\eta(3\pi^0)$

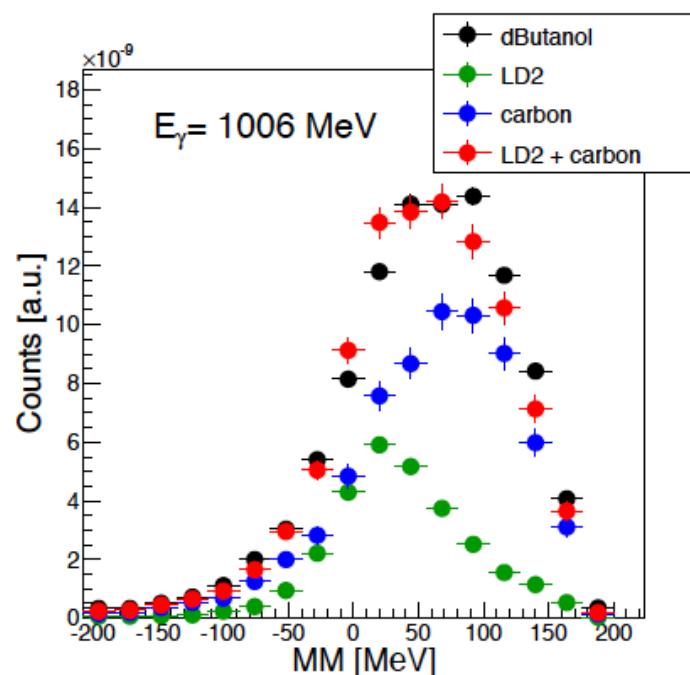
PhD work of
L.Witthauer & M.Dieterle



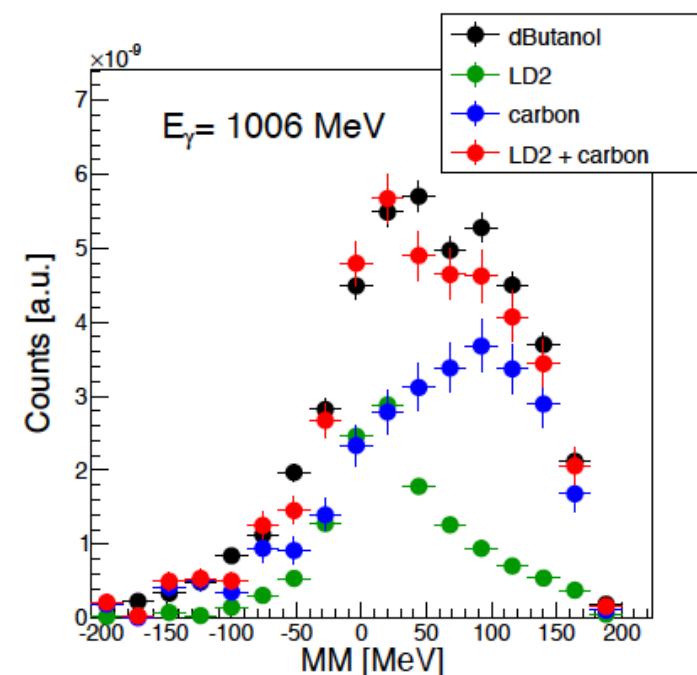
Proton



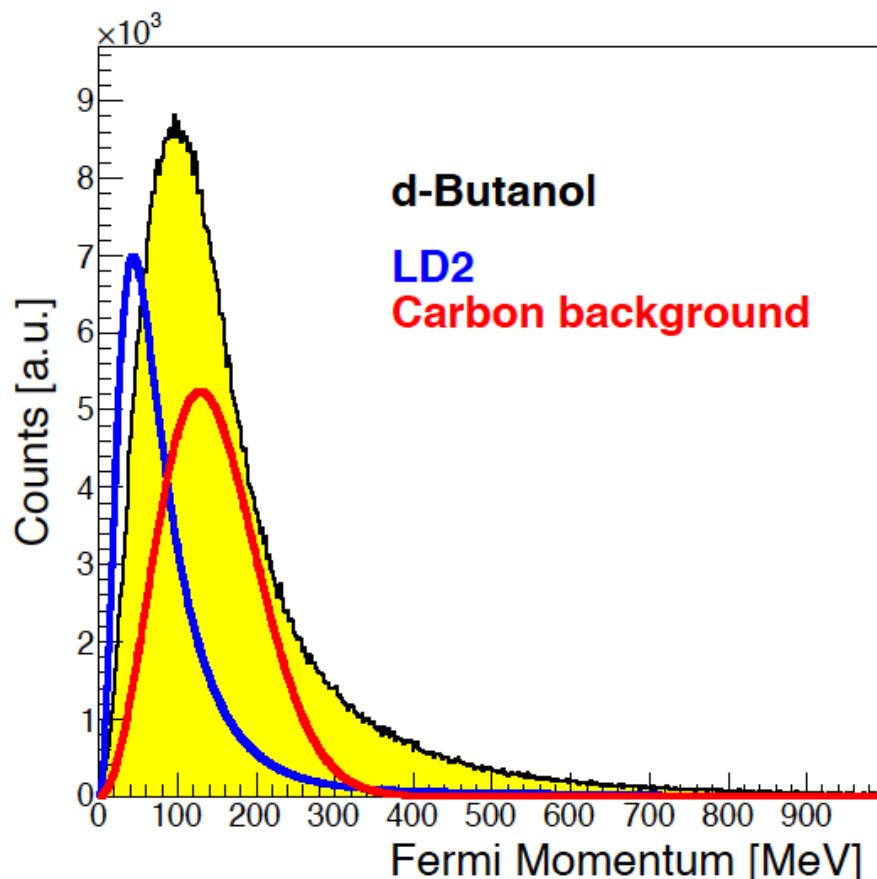
Neutron

Scale LD₂: $\frac{\#p \text{ in d-Butanol}}{\#p \text{ in LD2}}$ 

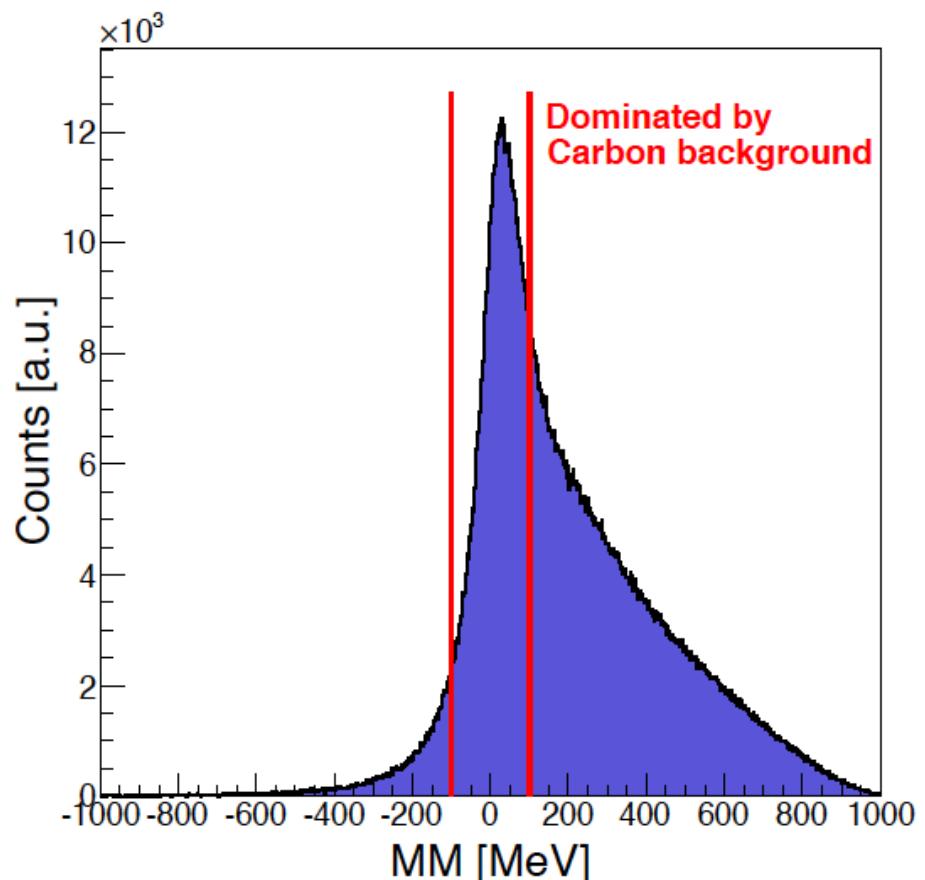
Proton

Scale Carbon: $\frac{\#p \text{ in C}_4\text{O}}{\#p \text{ in Carbon}}$ 

Neutron

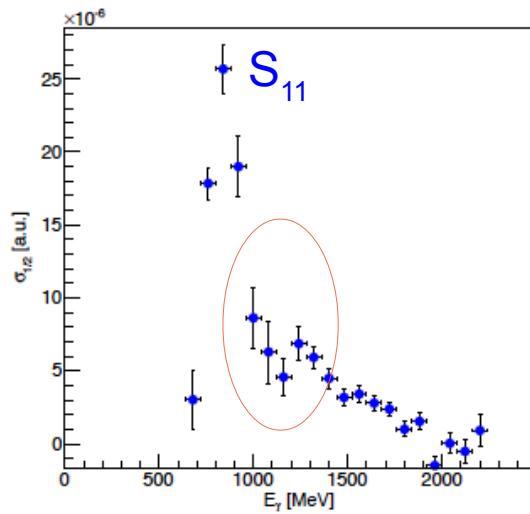
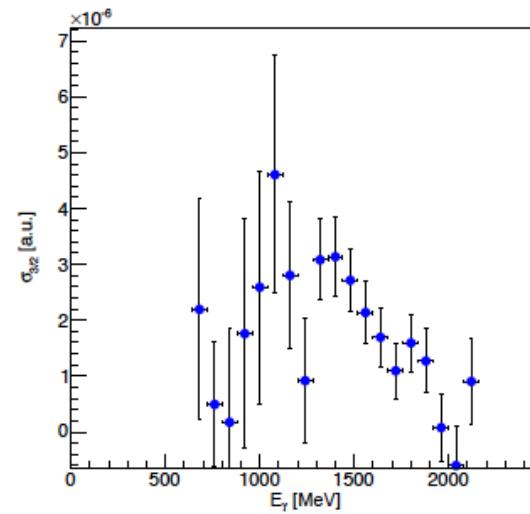


$$(\vec{p}_N + \vec{p}_{2\pi^0}) - \vec{p}_\gamma$$

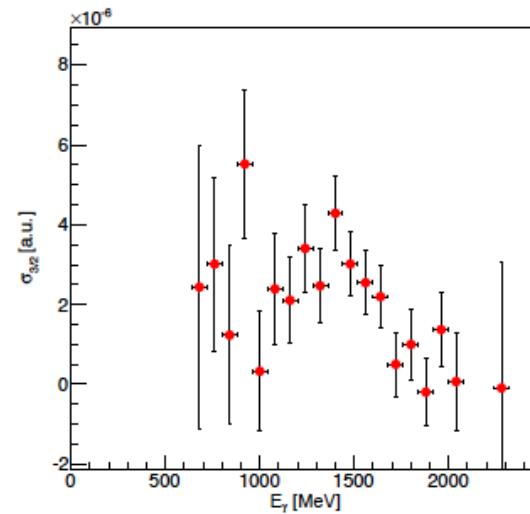
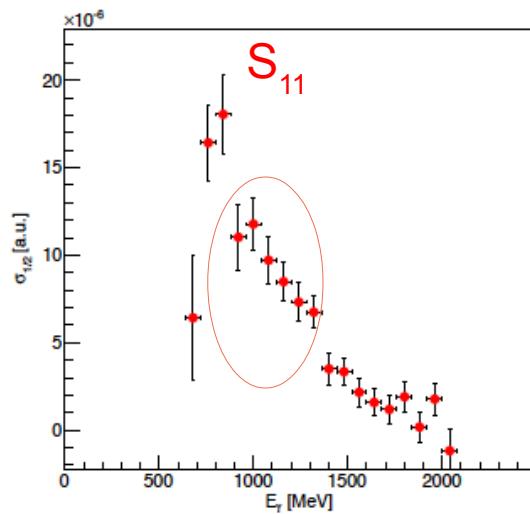


$$M(\gamma + N - 2\pi^0) - m_N$$

Proton

 $\sigma_{3/2}$ 

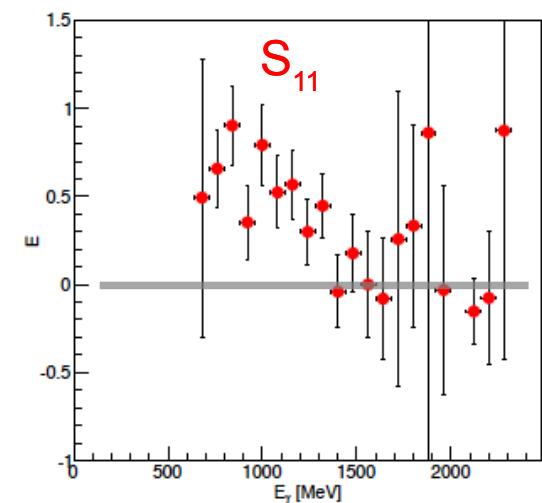
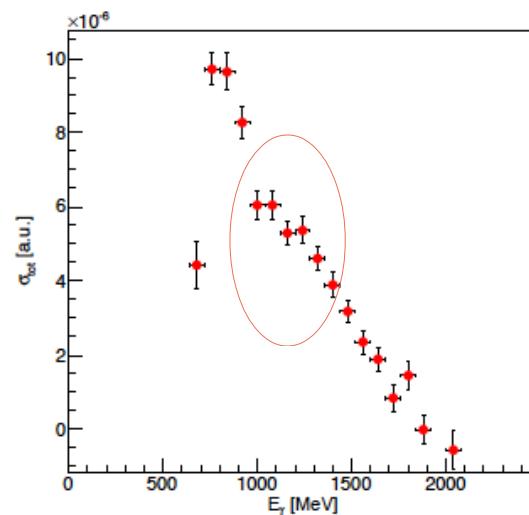
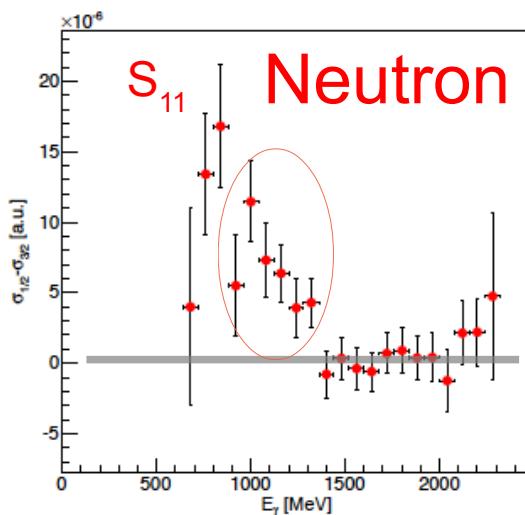
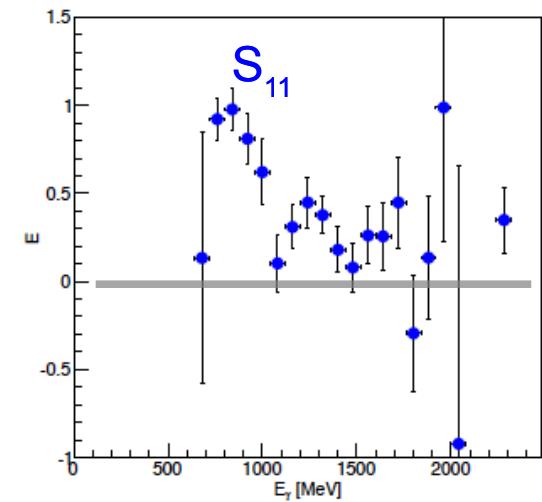
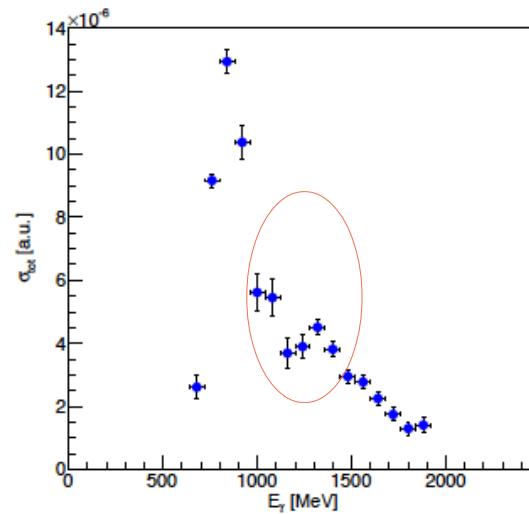
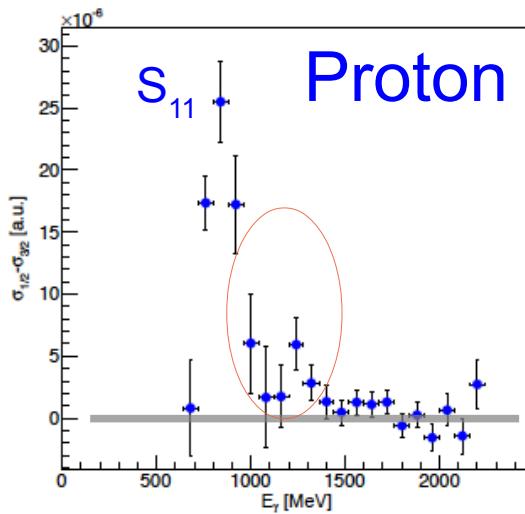
Neutron

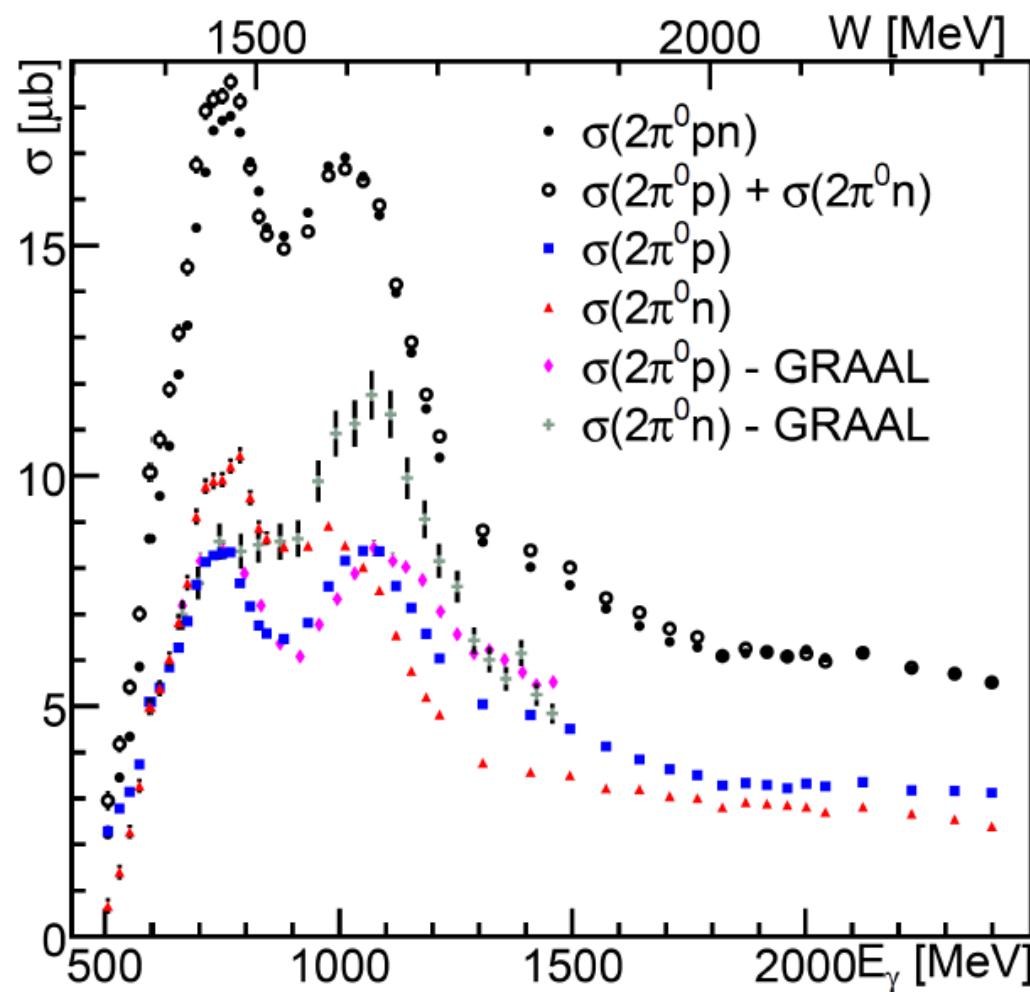
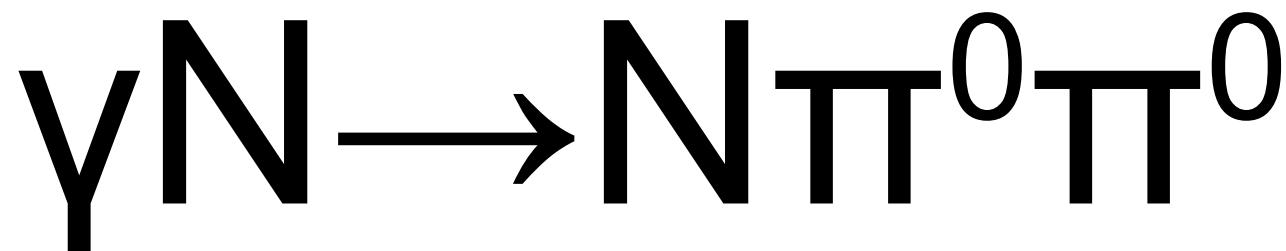


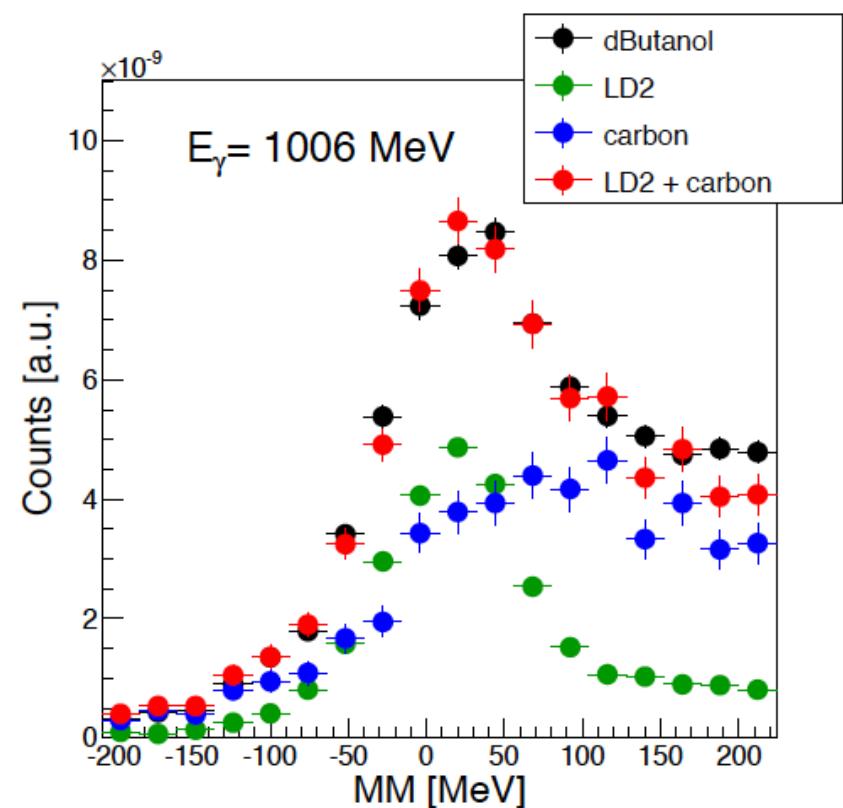
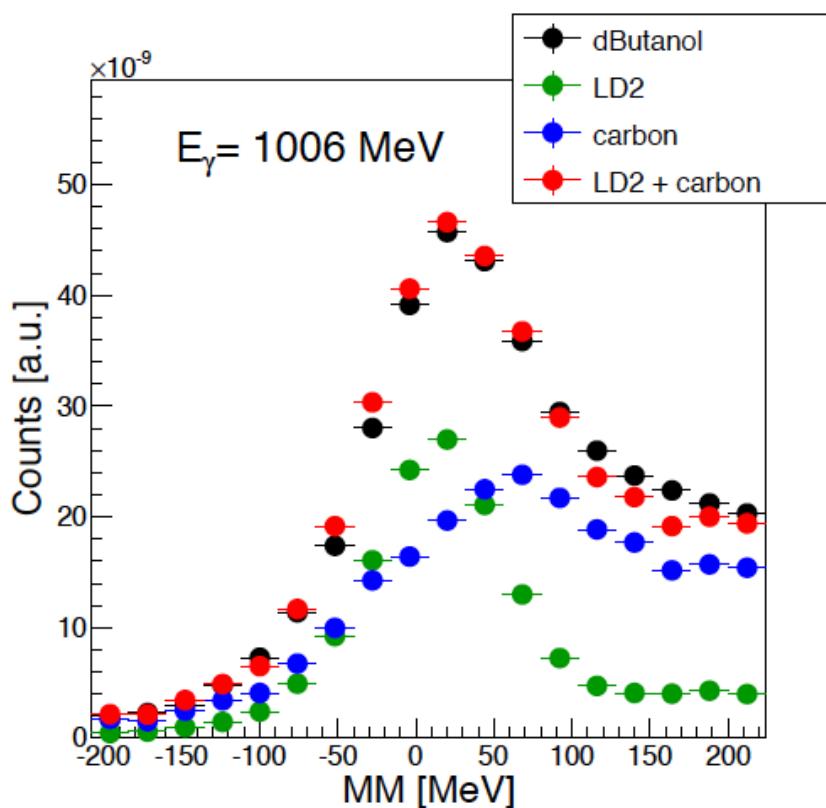
$\sigma_{1/2} - \sigma_{3/2}$

σ_{tot}

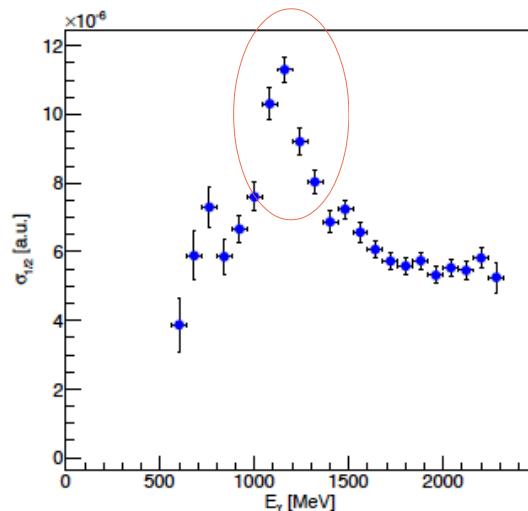
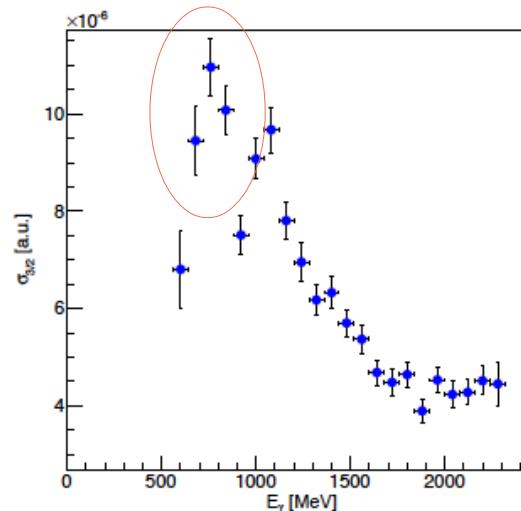
$E = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{3/2}} \frac{1}{P_\gamma P_T}$



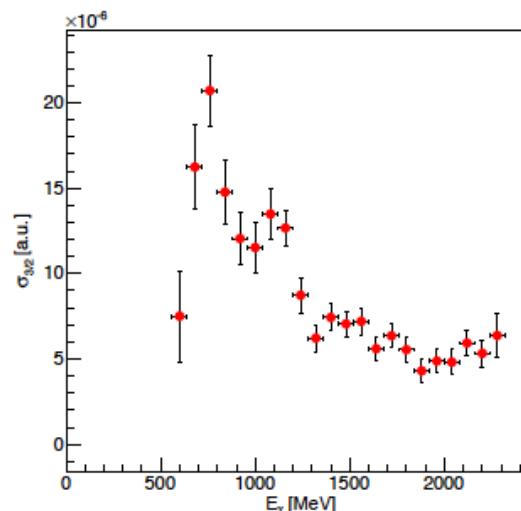
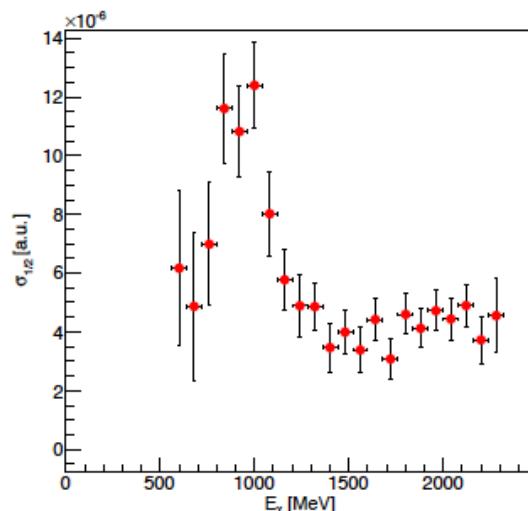


Scale LD₂: $\frac{\#p \text{ in d-Butanol}}{\#p \text{ in LD2}}$ Scale Carbon: $\frac{\#p \text{ in C}_4\text{O}}{\#p \text{ in Carbon}}$ 

Proton

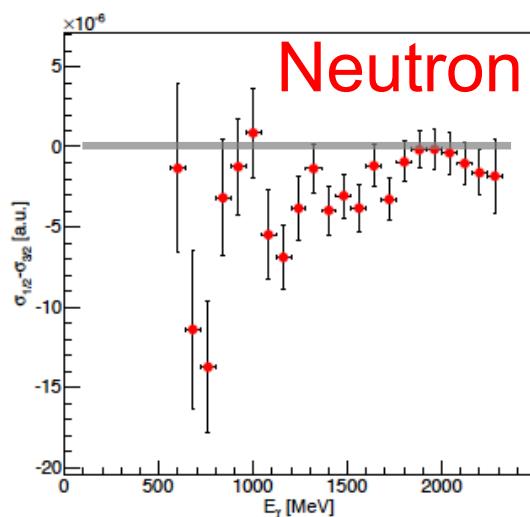
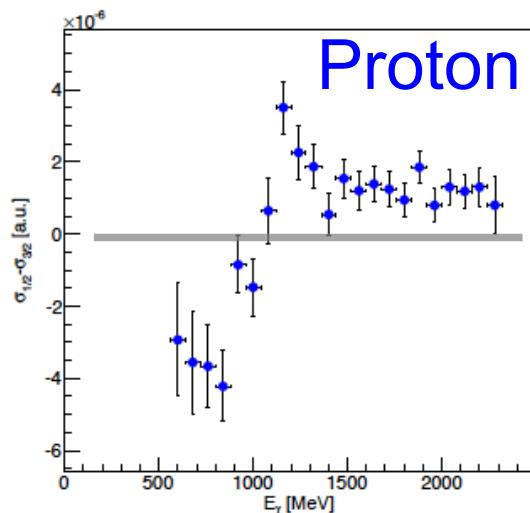
 $\sigma_{1/2}$  $\sigma_{3/2}$ 

Neutron

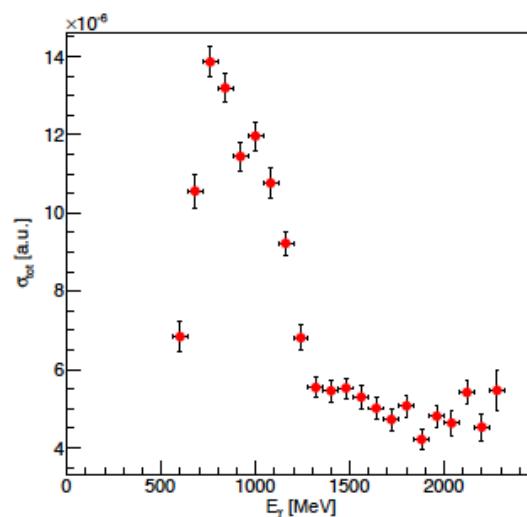
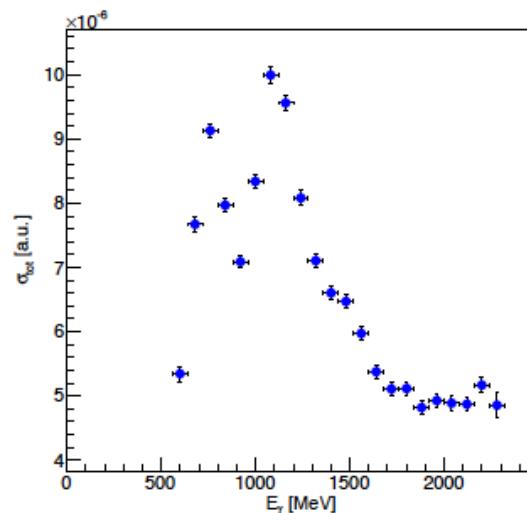


$\gamma N \rightarrow N \pi^0 \pi^0$

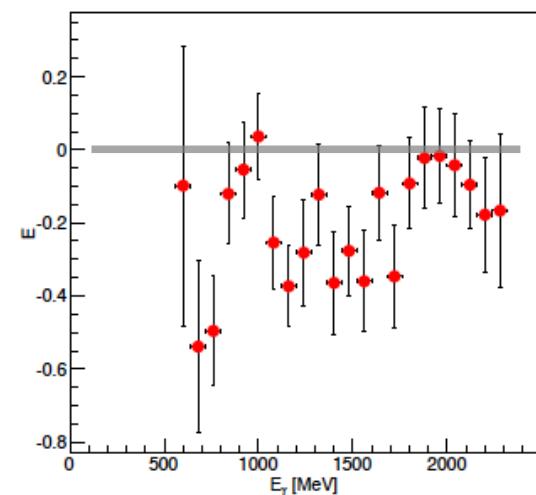
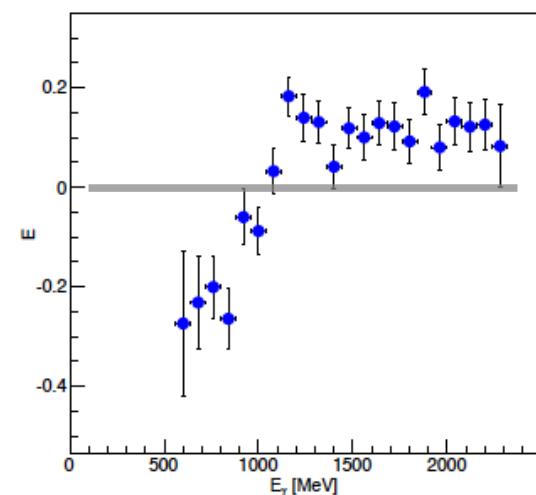
$$\sigma_{1/2} - \sigma_{3/2}$$

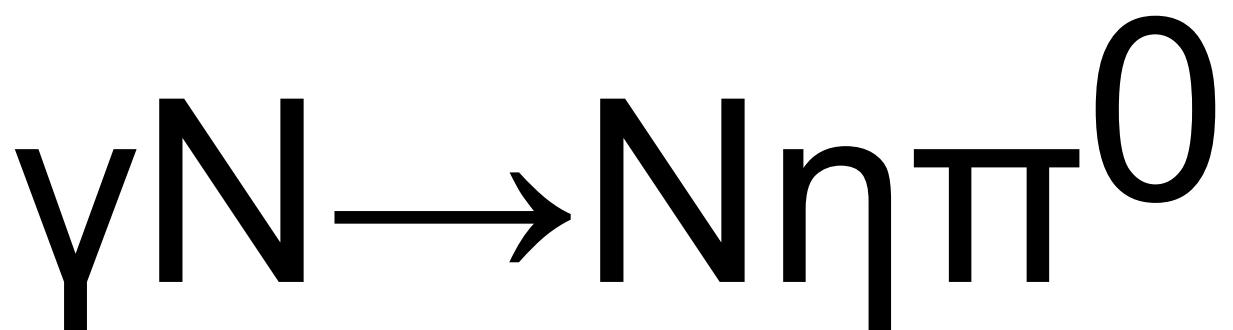


$$\sigma_{\text{tot}}$$



$$E = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{3/2}} \frac{1}{P_\gamma P_T}$$

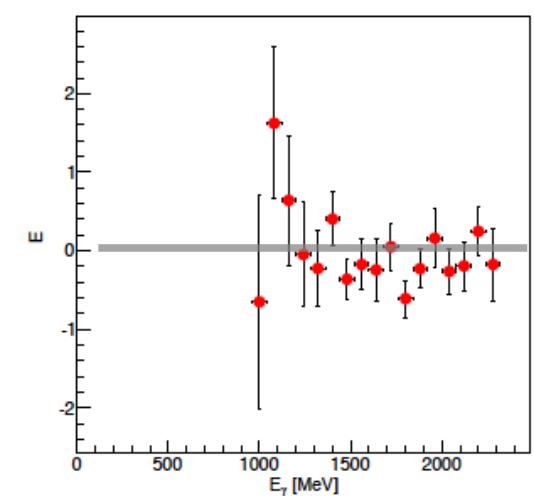
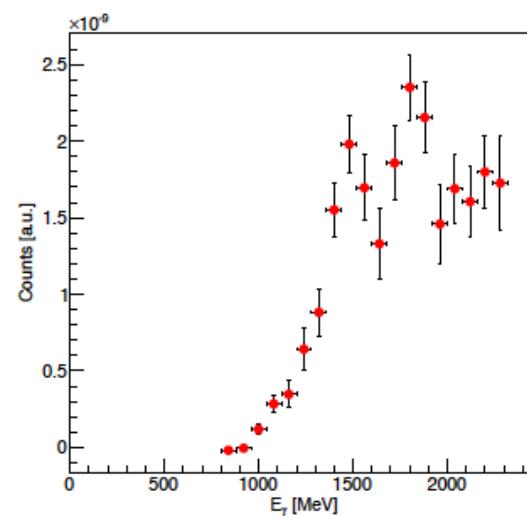
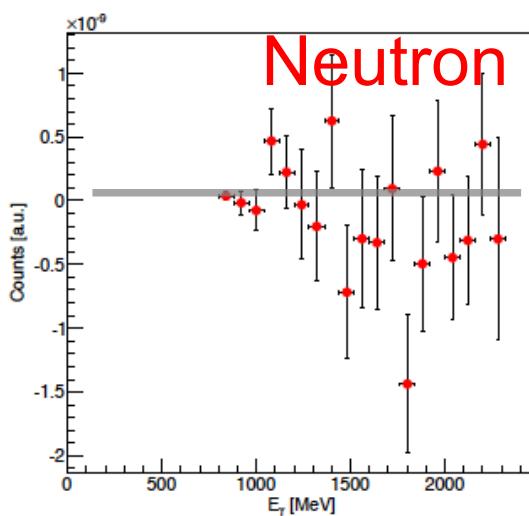
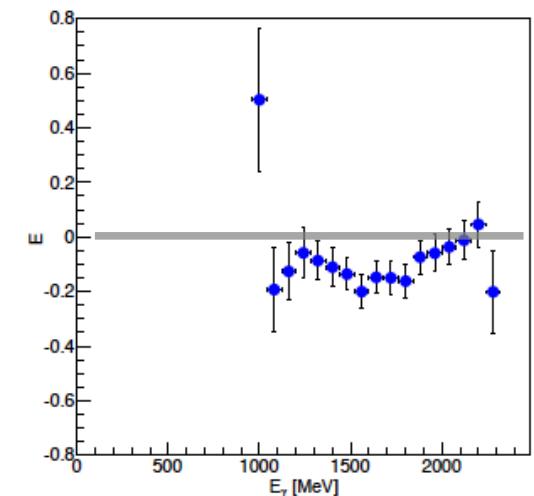
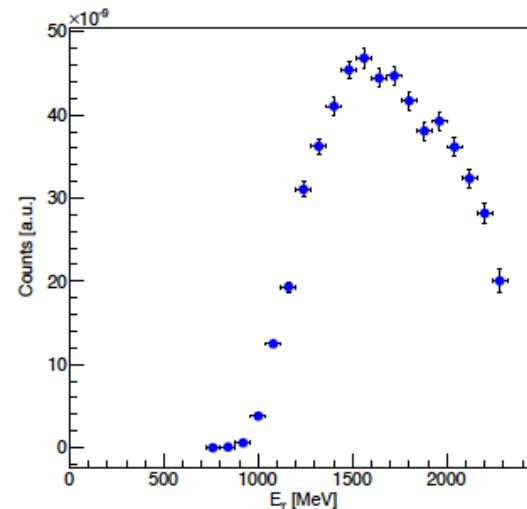
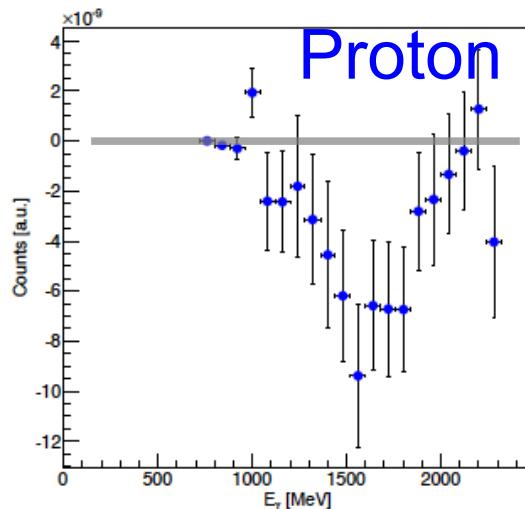




$\sigma_{1/2} - \sigma_{3/2}$

σ_{tot}

$E = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{3/2}} \frac{1}{P_\gamma P_T}$



Less Statistics,
Less Conclusions :)

Thank you for your Attention

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